Stormwater Quality Plan

Town of Rib Mountain, Wisconsin

MSA Project No. R09459003

December 22, 2017

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1.0 EXECUTIVE SUMMARY

This report documents the findings of a study conducted for purposes of determining the pollutant load reduction achieved by the Town of Rib Mountain's stormwater management system. This study was completed to determine the Town's compliance with WPDES General Permit WI-S050075-2 which references the standards for Total Suspended Solids (TSS) reductions as required by Wisconsin Administrative Code NR151.13. General Permit WI-S050075-2 also includes requirements for achieving additional pollutant reductions (most commonly Total Phosphorus, TP) in accordance with approved Total Maximum Daily Load (TMDL) studies.

The standards outlined within NR151 require that regulated communities achieve a 20% reduction in TSS in runoff that enters waters of the state, relative to no controls. A TMDL study for the Wisconsin River is expected to be approved by WDNR and USEPA in 2018. When approved, the Wisconsin River TMDL will assign a "wasteload allocation" for TP in addition to a wasteload allocation for TSS. It is expected that the requirements of the TMDL will exceed the minimum TSS reduction requirement of NR 151. Until the TDML is approved, and results are released, the actual performance targets for control of the two pollutants is unknown.

The findings of this study are taken from a detailed WinSLAMM Version 10.2 water quality model of the urbanized area of the Town, along with other areas of the Town which drain through the urbanized area. Together these areas make up the "Study Area". Only the urbanized area within the Town, as determined by the US Census Bureau, is regulated. The Town is required (and currently has obtained) permit coverage for stormwater discharges from the urbanized area under WPDES General Permit No. WI-S050075-2. This permit is commonly known as an MS4 Permit.

The WinSLAMM model was used to evaluate TSS and TP reduction provided by a network of 52 stormwater management ponds within the Town, as well as 61 miles of eligible roadside swales. The results from each model describing the regulated TSS and TP loads (inclusive of all areas within the Town's urbanized area) are summarized in Tables 1 and 2 below, respectively.

TABLE 1
Town of Rib Mountain Current Total Suspended Solids Reduction Performance

Urbanized Area	**Total Load**		**TSS Removed by Existing BMPs**	
Acres	tons/yr	lbs/ac/yr	tons/yr	%
2,432	283.0	232.7	194.4	68.7%

TABLE 2
Town of Rib Mountain Current Total Phosphorus Reduction Performance

Urbanized Area	Total Load		TP Removed by Existing BMPs	
Acres	lbs/yr	lbs/ac/yr	lbs/yr	%
2,432	1,608	0.66	1,012	62.9%

With its current management practices, the Town of Rib Mountain achieves a 68.7% TSS reduction and a 62.9% TP reduction within the urbanized area, which exceeds the current regulatory of NR 216 and NR 151. The TSS and TP reduction requirement which the Town may be required to achieve to meet the conditions of the Wisconsin River TMDL

2.0 INTRODUCTION

Portions of the Town of Rib Mountain are considered "urbanized area" by the US Census Bureau. Wisconsin Adminstrative Code NR216.02(3) requires operators of Municipal Separate Storm Sewer Systems within urban areas and comply with the standards specified in Wisconsin rules NR151 and NR216. NR216.07(6)(b) and NR151.13(2)(b) collectively require regulated municipalities to achieve 20% and 40% reductions in total suspended solids in runoff that enters waters of the state according to a certain schedule. 2011 Wisconsin Act 32 amended the language of applicable state statutes prohibiting establishing a date by which a community must achieve compliance with the 40% reduction standard. This study was completed to determine the Town's current level of water quality performance as compared to the current requirements of NR 151 and NR 216 as well as the pending requirements of the Wisconsin River TMDL.

3.0 WATER QUALITY MODELING

The findings of this study are taken from a detailed WinSLAMM Version 10.2 model of the Town's stormwater management system. WinSLAMM is a Wisconsin Department of Natural Resources (WDNR) approved model recommended for use in determining TSS removal rates from stormwater management practices for assessment of compliance with WPDES requirements (see notation NR216.07(6)(b) – "The department believes that computer modeling is the most efficient and cost effective method for calculating pollutant loads. Pollutant loading models such as [Win]SLAMM, P8 or equivalent methodology may be used to evaluate the efficiency of the design in reducing total suspended solids.") 'WinSLAMM' abbreviates "Source Loading and Management Model [for Windows]."

SLAMM was originally developed to better understand the relationships between sources of urban runoff pollutants and runoff quality. It has been continually expanded since the late 1970s and has been revised to include a wide variety of source area (runoff and pollutant generators) and outfall control practices (runoff and pollutant management practices). SLAMM is based on actual field observations and has minimal reliance on theoretical processes.

Input data required by WinSLAMM for each model application includes a number of data files that describe local meteorological and hydrological conditions and pollutant loading characteristics. These files are prescribed for use in the WinSLAMM model by the USGS Wisconsin Water Science Center and include parameter files for rainfall, pollutant distribution, runoff coefficients, particulate solids concentrations, and pollutant delivery data.

3.1 RAINFALL DATA

The USGS has evaluated rainfall data collected across the state of Wisconsin for many years and has identified annual rainfall records for five locations in the state that are felt to be representative of typical rainfall precipitation conditions. For Rib Mountain, the closest rainfall record recommended for use in water quality modeling is the Green Bay five-year rainfall record starting in 1969 (a five-year model run is specified by WDNR for evaluations which include street sweeping or catch basins). Modeling protocols established by WDNR require elimination of the winter season (where precipitation principally falls as snow or ice) from the model simulation as WinSLAMM cannot accommodate snowfall and runoff from snowmelt events. The range of winter dates applicable to the Green Bay rainfall data run from November 25 to March 29. Thus, any single-year simulation runs from March 29 to November 25.

3.2 WinSLAMM POLLUTANT LOADING FILES

Pollutant loading files required by the WinSLAMM model include a *Pollutant Probability Distribution File, Runoff Coefficient File, Particulate Solids Concentration File, a Street Delivery Parameter File, and a Source Area Particle Distribution File.*

The *Pollutant Probability Distribution File* describes the pollutant loading from different source areas (land use types). This data is based upon actual pollutant loading collected from the study area or region.

The *Runoff Coefficient File* describes parameters specific to different source areas (land use types) that determine the runoff volumes resulting from rainfall events of different depth.

The *Particulate Solids Concentration File* contains parameters allowing the WinSLAMM model to determine the weight of particulate solids loadings resulting from runoff events of different volumes. The particulate solids concentration file includes data measured by the USGS from source areas including residential, commercial, and industrial rooftops; residential lawns; residential driveways; residential, commercial and industrial streets; commercial and industrial parking lots; freeways; and undeveloped areas.

The *Street Delivery Parameter File* contains data describing the fraction of total particulates that do not reach the outfall during a rain event, for different rain depths and street textures.

The *Source Area Particle Distribution File* provides the default particle size distribution files for each source area within each land use type.

3.3 MODEL PARAMETER FILES

The following model parameter files were entered into the WinSLAMM model(s) for evaluation of the Town of Rib Mountain's stormwater management system.

Rainfall Files -	***WisReg – Green Bay Five Year Rainfall.ran***
Pollutant Probability Distribution File -	***WI_GEO03.ppdx***
Runoff Coefficient File -	***WI_SL06 Dec06.rsv***
Particulate Solids Concentration File -	***v10.1 WI_avg01.pscx***
Street Delivery File:	
Residential/Other -	***WI_Res and Other Urban Dec06.std***
Institutional/Commercial/Industrial -	***WI_Com Inst Indust Dec06.std***
Freeway -	***Freeway Dec06.std***
Source Area Particle Distribution File -	***NURP Source Area PSD Files.csv***

3.4 WATERSHEDS, LAND USES, SOURCE AREAS, AND SOIL TYPES.

Watersheds are the sources of runoff and pollutants simulated by the program. WinSLAMM Version 10 is capable of modeling complex systems of interconnected *watersheds* each of which can contain up to six discrete *land uses*; residential, institutional, commercial, industrial, freeway, and other urban areas. Each land use contains specific runoff and pollutant *source areas* including roofs, paved parking/storage areas, unpaved parking/storage areas, playground, driveways, sidewalks/walks, street areas, landscaped areas (small and large), undeveloped areas, isolated/water body area, other pervious areas and impervious areas (directly connected and indirectly connected). Each source area is further categorized by *soil texture*, including sand, silt, and clay soil types.

3.4.1 Determination of Watershed Boundaries

For this study, watershed areas draining to existing or proposed water quality management practices were delineated using the GIS program ArcMap 10.4. Delineation of watersheds was completed using two-foot contour interval topographic maps.

The water quality modeling study area includes the urbanized area and those areas outside the urbanized area that drain via sheet flow or constructed drainage infrastructure to an existing structural stormwater quality management practice within the urbanized area. The urbanized area includes approximately 2,432 acres, and the areas outside of but draining through the urbanized area include 1,652. Map-1, 'Study Area Limits' identifies the limits of the study area, which includes approximately 4,084 acres. Maps can be found in Appendix A.

3.4.2 Development of WinSLAMM Land Use Data

Land uses within the study area were assigned by MSA, based on several data sources beginning with a GIS parcel layer provided by Marathon County. Each parcel within the Study Area was assigned a unique land use, based on a visual review of aerial imagery, parcel ownership information, and Google Street View images. Land uses were assigned to match built-in WinSLAMM standard land use classifications. Land uses included in the model are shown on Table 3 on the following page. Highways were added to the parcel-based land use manually, and classified based on the Annual Average Daily Traffic (AADT, WisDOT), location in a rural or urban setting, the number of lanes, and the presence of curb and gutter.

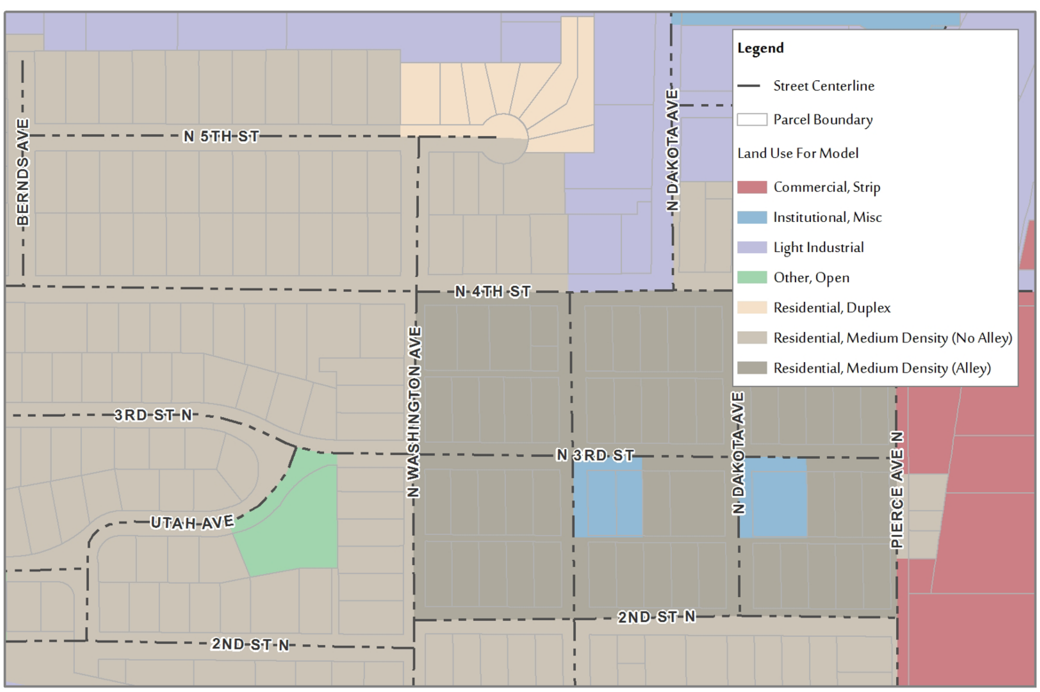
For the non-highway street right-of-way (ROW) areas, MSA created a generalized 'ROW' polygon (covering all regions not classified within the original land use dataset – i.e. areas not defined as parcels). This new polygon was then divided along the street centerlines with the resulting pieces assigned land use according to the classification of the adjacent parcel. Figure 1, on the following page, provides a generic example of how this was accomplished.

Map-2 in Appendix A identifies WinSLAMM land uses within the study area.

TABLE 3
Land Use Classifications Applied to Rib Mountain WinSLAMM Models

Commercial, Shopping Center	Open Space
Commercial, Strip	Other Pervious
Highway: 6 lanes rural with median 55000 AADT S1	Park
Highway: 6 lanes urban with median 55000 AADT S2	Residential, Duplex
Industrial, Light	Residential, High Density (No Alley)
Industrial, Medium	Residential, Low Density
Institutional, Misc.	Residential, Medium Density (No Alley)
Institutional, School	Residential, Multi-Family
Office Park	Water

FIGURE 1
Illustration of how Land Use Classifications were assigned to ROW areas.



3.4.3 Development of WinSLAMM Soil Texture Data

WinSLAMM requires that the soil underlying all source areas be classified by texture as *sand, silt, or clay*. The WinSLAMM 'Frequently Asked Questions (FAQ)' document on the WinSLAMM web site (http://winslamm.com/faq.html) states that soil textures are to be assigned according to the hydrologic soil group (HSG) assigned each soil type by to the USDA county soil atlas; 'When we set up the soil classifications clayey, silty and sandy, we assumed that they would correspond to the SCS classification A, B, C, and D soils, with: A – Sandy, B – Silty, C and D - Clayey.'

Table 4, below and on the following pages, identifies the soil types within the project study area identified in the Marathon County Soil Atlas and identifies the soil texture class assigned to each soil for entry into WinSLAMM according to the relationship described above. Soils with a dual classification such as B/D indicate the HSG of the soil in a drained and undrained condition, respectively. Soils were assumed to be drained as this is a common condition in urban areas.

Map 3 in Appendix A identifies the locations within the study area where sandy, silty, and clayey soils were applied in this study.

TABLE 4
Study Area Soil Textures

Soil Map Unit	Soil Names	Hydrologic Soil Group (HSG)	WinSLAMM Soil Texture
MsD	Mosinee sandy loam, 12 to 20 percent slopes	A	Sand
DuB	Dunnville fine sandy loam, 1 to 4 percent slopes	A	Sand
MsB	Mosinee sandy loam, 2 to 6 percent slopes	A	Sand
McA	Mahtomedi loamy sand, moderately well drained, 0 to 3 percent slopes	A	Sand
MsB	Mosinee sandy loam, 2 to 6 percent slopes	A	Sand
MdC	Marathon silt loam, 6 to 12 percent slopes	B	Silt
RbE	Ribhill cobbly silt loam, 15 to 30 percent slopes, stony	C	Clay
Fh	Fordum silt loam, 0 to 1 percent slopes	B	Silt
DuB	Dunnville fine sandy loam, 1 to 4 percent slopes	A	Sand
St	Sturgeon silt loam, 0 to 2 percent slopes	B	Silt
UoB	Udorthents, loamy, gently sloping	A	Sand
St	Sturgeon silt loam, 0 to 2 percent slopes	B	Silt
St	Sturgeon silt loam, 0 to 2 percent slopes	B	Silt
Da	Dancy sandy loam, 0 to 2 percent slopes	B	Silt

Soil Map Unit	Soil Names	Hydrologic Soil Group (HSG)	WinSLAMM Soil Texture
Fh	Fordum silt loam, 0 to 1 percent slopes	B	Silt
RbC	Ribhill cobbly silt loam, 6 to 15 percent slopes, stony	C	Clay
Fh	Fordum silt loam, 0 to 1 percent slopes	B	Silt
MsC	Mosinee sandy loam, 6 to 12 percent slopes	A	Sand
DuB	Dunnville fine sandy loam, 1 to 4 percent slopes	A	Sand
GuB	Guenther loamy sand, 2 to 6 percent slopes	B	Silt
RbE	Ribhill cobbly silt loam, 15 to 30 percent slopes, stony	C	Clay
MsB	Mosinee sandy loam, 2 to 6 percent slopes	A	Sand
FfC	Fenwood silt loam 2 to 15 percent slopes, stony	B	Silt
MgA	Meadland loam, 0 to 3 percent slopes	B	Silt
MsB	Mosinee sandy loam, 2 to 6 percent slopes	A	Sand
MbE	Mahtomedi loamy sand, 15 to 45 percent slopes	A	Sand
ScA	Scott Lake sandy loam, 0 to 3 percent slopes	C	Clay
MsB	Mosinee sandy loam, 2 to 6 percent slopes	A	Sand
FeC	Fenwood silt loam, 6 to 12 percent slopes	B	Silt
Ch	Cathro muck, 0 to 1 percent slopes	B	Silt
MbE	Mahtomedi loamy sand, 15 to 45 percent slopes	A	Sand
Fh	Fordum silt loam, 0 to 1 percent slopes	B	Silt
CkA	Chetek sandy loam, 0 to 2 percent slopes	B	Silt
RbC	Ribhill cobbly silt loam, 6 to 15 percent slopes, stony	C	Clay
MsC	Mosinee sandy loam, 6 to 12 percent slopes	A	Sand
MbE	Mahtomedi loamy sand, 15 to 45 percent slopes	A	Sand
MbB	Mahtomedi loamy sand, 0 to 6 percent slopes	A	Sand
MbC	Mahtomedi loamy sand, 6 to 15 percent slopes	A	Sand
MsB	Mosinee sandy loam, 2 to 6 percent slopes	A	Sand
MtC	Mosinee sandy loam, 2 to 15 percent slopes, stony	A	Sand
St	Sturgeon silt loam, 0 to 2 percent slopes	B	Silt
CkB	Chetek sandy loam, 2 to 6 percent slopes	B	Silt
FgB	Fenwood-Rozellville silt loams, 2 to 6 percent slopes	B	Silt
MgA	Meadland loam, 0 to 3 percent slopes	B	Silt
MbB	Mahtomedi loamy sand, 0 to 6 percent slopes	A	Sand
Oe	Oesterle loam, 0 to 2 percent slopes	B	Silt
DuB	Dunnville fine sandy loam, 1 to 4 percent slopes	A	Sand
MsB	Mosinee sandy loam, 2 to 6 percent slopes	A	Sand
Mm	Meehan loamy sand, 0 to 2 percent slopes	A	Sand
RhA	Rockers loamy sand, 0 to 3 percent slopes	C	Clay

Soil Map Unit	Soil Names	Hydrologic Soil Group (HSG)	WinSLAMM Soil Texture
McA	Mahtomedi loamy sand, moderately well drained, 0 to 3 percent slopes	A	Sand
Ch	Cathro muck, 0 to 1 percent slopes	B	Silt
Fh	Fordum silt loam, 0 to 1 percent slopes	B	Silt
Ch	Cathro muck, 0 to 1 percent slopes	B	Silt
RhA	Rockers loamy sand, 0 to 3 percent slopes	C	Clay
Pg	Pits, gravel	B	Silt
RhA	Rockers loamy sand, 0 to 3 percent slopes	C	Clay
GuB	Guenther loamy sand, 2 to 6 percent slopes	B	Silt
CkB	Chetek sandy loam, 2 to 6 percent slopes	B	Silt
MsB	Mosinee sandy loam, 2 to 6 percent slopes	A	Sand
McA	Mahtomedi loamy sand, moderately well drained, 0 to 3 percent slopes	A	Sand
GuB	Guenther loamy sand, 2 to 6 percent slopes	B	Silt
ReB	Rietbrock silt loam, 1 to 8 percent slopes, stony	B	Silt
Pg	Pits, gravel	A	Sand
MbE	Mahtomedi loamy sand, 15 to 45 percent slopes	A	Sand
Fh	Fordum silt loam, 0 to 1 percent slopes	B	Silt
MbB	Mahtomedi loamy sand, 0 to 6 percent slopes	A	Sand
UoB	Udorthents, loamy, gently sloping	A	Sand
FfE	Fenwood silt loam, 15 to 30 percent slopes, stony	B	Silt
RbC	Ribhill cobbly silt loam, 6 to 15 percent slopes, stony	C	Clay
FeC	Fenwood silt loam, 6 to 12 percent slopes	B	Silt
Mm	Meehan loamy sand, 0 to 2 percent slopes	A	Sand
GuB	Guenther loamy sand, 2 to 6 percent slopes	B	Silt
Mn	Minocqua sandy loam, 0 to 2 percent slopes	B	Silt
ReB	Rietbrock silt loam, 1 to 8 percent slopes, stony	B	Silt
RcB	Rietbrock silt loam, 1 to 8 percent slopes	B	Silt
Oe	Oesterle loam, 0 to 2 percent slopes	B	Silt
UoB	Udorthents, loamy, gently sloping	A	Sand
MbE	Mahtomedi loamy sand, 15 to 45 percent slopes	A	Sand
RbE	Ribhill cobbly silt loam, 15 to 30 percent slopes, stony	C	Clay
FfE	Fenwood silt loam, 15 to 30 percent slopes, stony	B	Silt
MbB	Mahtomedi loamy sand, 0 to 6 percent slopes	A	Sand
MbB	Mahtomedi loamy sand, 0 to 6 percent slopes	A	Sand
DuB	Dunnville fine sandy loam, 1 to 4 percent slopes	A	Sand
MsC	Mosinee sandy loam, 6 to 12 percent slopes	A	Sand

Soil Map Unit	Soil Names	Hydrologic Soil Group (HSG)	WinSLAMM Soil Texture
ReB	Rietbrock silt loam, 1 to 8 percent slopes, stony	B	Silt
Fh	Fordum silt loam, 0 to 1 percent slopes	B	Silt
McA	Mahtomedi loamy sand, moderately well drained, 0 to 3 percent slopes	A	Sand
FgB	Fenwood-Rozellville silt loams, 2 to 6 percent slopes	B	Silt
Mn	Minocqua sandy loam, 0 to 2 percent slopes	B	Silt
RcB	Rietbrock silt loam, 1 to 8 percent slopes	B	Silt
MdB	Marathon silt loam, 2 to 6 percent slopes	B	Silt
RcB	Rietbrock silt loam, 1 to 8 percent slopes	B	Silt
FgB	Fenwood-Rozellville silt loams, 2 to 6 percent slopes	B	Silt
MsC	Mosinee sandy loam, 6 to 12 percent slopes	A	Sand
GuB	Guenther loamy sand, 2 to 6 percent slopes	B	Silt
RhA	Rockers loamy sand, 0 to 3 percent slopes	C	Clay
GuB	Guenther loamy sand, 2 to 6 percent slopes	B	Silt
MdB	Marathon silt loam, 2 to 6 percent slopes	B	Silt
MsC	Mosinee sandy loam, 6 to 12 percent slopes	A	Sand
FgB	Fenwood-Rozellville silt loams, 2 to 6 percent slopes	B	Silt
Ne	Newson mucky loamy sand, 0 to 1 percent slopes	A	Sand
MdB	Marathon silt loam, 2 to 6 percent slopes	B	Silt
MsB	Mosinee sandy loam, 2 to 6 percent slopes	A	Sand
MsC	Mosinee sandy loam, 6 to 12 percent slopes	A	Sand
FgB	Fenwood-Rozellville silt loams, 2 to 6 percent slopes	B	Silt
GuB	Guenther loamy sand, 2 to 6 percent slopes	B	Silt
FgB	Fenwood-Rozellville silt loams, 2 to 6 percent slopes	B	Silt
FfE	Fenwood silt loam, 15 to 30 percent slopes, stony	B	Silt
MsC	Mosinee sandy loam, 6 to 12 percent slopes	A	Sand
Oe	Oesterle loam, 0 to 2 percent slopes	B	Silt
FgB	Fenwood-Rozellville silt loams, 2 to 6 percent slopes	B	Silt
Da	Dancy sandy loam, 0 to 2 percent slopes	B	Silt
Ch	Cathro muck, 0 to 1 percent slopes	B	Silt
FeC	Fenwood silt loam, 6 to 12 percent slopes	B	Silt
FeC	Fenwood silt loam, 6 to 12 percent slopes	B	Silt
RbC	Ribhill cobbly silt loam, 6 to 15 percent slopes, stony	C	Clay
GuB	Guenther loamy sand, 2 to 6 percent slopes	B	Silt

3.5 WATER QUALITY MANAGEMENT PRACTICES

WinSLAMM allows for assignation of water quality management practices for individual *source areas* within a land use type, within the *drainage system* serving the watershed, or at the '*outfall*' (point of discharge of the watershed). The Town of Rib Mountain relies in large part upon vegetated swale systems as well as five (5) regional detention basins within the USH 51 right of way. Additionally, MSA identified 23 individual stormwater BMPs tributary to the regional basins and 24 individual BMPs not tributary to the regional basins. All of these BMPs have been included in this model to the maximum extent practicable. Each practice was input into the model according to the structure identified in Table 5, below:

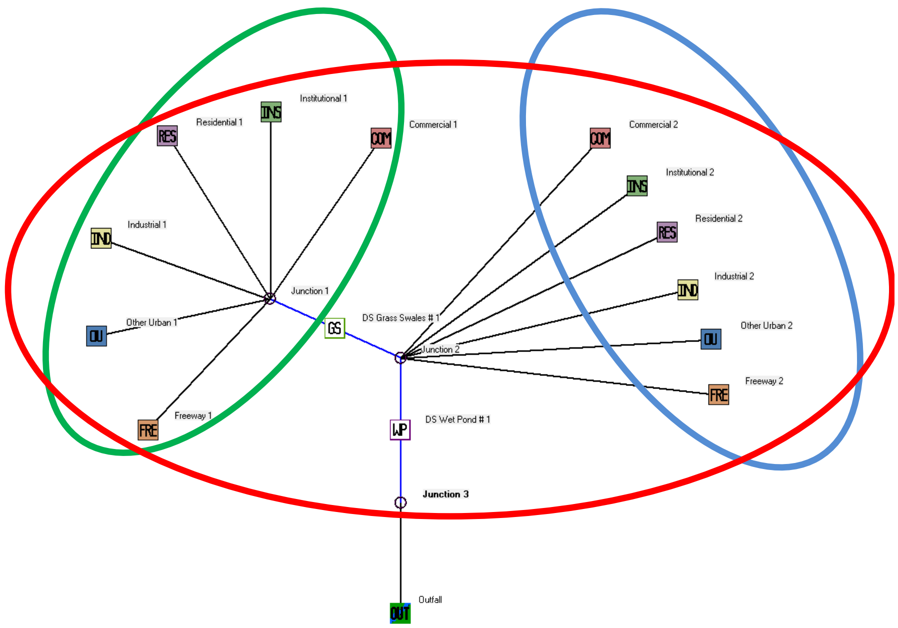
TABLE 5
Application of BMPs within WinSLAMM Model network

Practice	Level of Application within WinSLAMM
Vegetated Swales	Drainage System
Detention Ponds (Wet/Dry/Infiltration)	Outfall

The structure of any WinSLAMM model follows a cascading pattern; starting first with land uses which contain source areas; these are then connected to drainage system elements; and finally, outfall system elements. Figure 2, on the following page, presents a typical example of how any individual subwatershed in the Town of Rib Mountain WinSLAMM model might be expected to be constructed. The model nodes which are circled represent nodes describing drainage areas for various land uses and source areas. Each possible land use is included multiple times in the model network to reflect the portion of each watershed which flows to a swale or which drains direct to an outfall device. Note; not all land uses, drainage system BMPs, or outfall BMPs are found in every subwatershed evaluated in this study.

Maps 5 and 6 in the Appendix A of this report identify the locations where swales and stormwater detention ponds are located within the urbanized area.

FIGURE 2
Example WinSLAMM model Network Subwatershed Level



RED = All land uses within subwatershed
GREEN = Portion of subwatershed draining to swales
BLUE = Portion of subwatershed draining direct to pond
Note: Street sweeping is applied at source level within each land use.

3.5.1 Application of Vegetated Swales in WinSLAMM

Vegetated swales are management practices which have been historically defined as part of the *drainage system* level of a WinSLAMM model. However, with the evolution of WinSLAMM into version 10, the application of drainage system and outfall BMPs are treated similarly and are applied as nodes directly downstream from land use nodes (see Figure 2).

WinSLAMM requires several input parameters in order to define swales so as to evaluate their effectiveness at reducing pollutants in stormwater runoff. These parameters include; drainage area, swale density (expresses as length of swale per acre), average swale geometry (bottom width, side-slope, longitudinal slope), vegetation height, flow retardance factor, and infiltration rate.

3.5.1.1 Determining Swale Drainage Area and Density

The principal input parameters of drainage area and swale densities were determined using GIS. Town Public Works staff provided a hand-drawn map indicating the location of streets severed by roadside swales. MSA digitized the locations of these swales in GIS and manually delineated subwatershed areas tributary to the outfall of the collective swale system. The resulting exercise identified fifteen significant swale systems serving 2,283 acres of the urbanized area. This is almost 94% of the entire urbanized area. Swale density was then determined on a subwatershed basis by dividing the area of the subwatershed by the total length of swale within the subwatershed.

Map-5 in Appendix A identifies the location of vegetated swales and areas served by swales within the study area.

3.5.1.2 Determining Swale Geometry Data, Vegetative Conditions, and Infiltration Rates

In May and June 2015, MSA conducted field inspections of several swales throughout the Town of Rib Mountain. These inspections also included testing for infiltration rates using a double ring infiltrometer. Infiltrometer testing was performed by MSA and Town staff.

Typical Swale Geometry. MSA's observation of swale cross-sections revealed a typical bottom width of one foot, average swale side-slopes of approximately 4h:1v, and turf grass approximately 4 inches high.

Swale Longitudinal Slopes. A value describing the average slope of swales was determined for each subwatershed. Each swale segment identified in GIS was assigned an average slope based on a digital elevation model (DEM) derived from the 2-foot contour maps provided by the City. The average swale slope by subwatershed was then determined by taking a weighted average by length of all the swale segments within each individual watershed. Swales with slopes greater than 4% (without slope interruption devices) were not included in WinSLAMM modeling as required by WDNR modeling guidance.

Typical Grass Height and Swale Retardance Factor. The typical grass height was assigned to be 4-inches from visual observation. In January 2011, WDNR held a 'Consultant Round Table' where WDNR technical staff and the developers of the WinSLAMM model indicated that it was most appropriate to assign a retardance factor of 'D' to swales in residential lands. This value has been applied throughout the Town.

Swale Dynamic Infiltration Rates. As mentioned previously, a series of infiltration tests were conducted on swales within the Town of Rib Mountain in May and June of 2015. A total of twenty infiltration tests were performed, and the results of these tests are summarized in Appendix B of this report. MSA assigned infiltration rates to the Town's swales based on the predominant hydrologic soil group within the subwatershed. 'Dynamic infiltration' rates of 0.32 in/hr, 0.265 in/hr, and 0.06 in/hr were assigned to areas dominated by HSG A, HSG B, and HSG C soils, respectively. The dynamic infiltration rate is equal to 50% of the measured geometric mean values of the static infiltration rates observed for each soil group.

3.5.3 Application of Stormwater Detention Ponds in WinSLAMM

The WinSLAMM model is capable of modeling several configurations of ponds including wet detention ponds, dry detention ponds, and infiltration ponds. Each of these pond subtypes are included in the assessment of the Town's stormwater management system. Similar to how vegetated swales are treated in the modeling, stormwater detention ponds are applied as nodes directly downstream from land use nodes (see Figure 2).

WinSLAMM requires several input parameters in order to define stormwater detention ponds so as to evaluate their effectiveness at reducing pollutants in stormwater runoff. These parameters include; drainage area, storage volume (expresses as surface area at different elevations), and the configuration of outlet control structures (orifices, culverts, weirs, etc.). All ponds that were configured as dry or infiltration ponds were also assigned an infiltration rate.

3.5.2.1 Determining Pond Drainage Areas

Watershed areas draining to stormwater detention ponds were determined using GIS. The Town provided a GIS map identifying the locations of known stormwater detentions ponds which MSA supplemented through review of aerial topographic maps and photos as well as field inspections.

Map-6 in the Appendix A identifies the location of stormwater detention ponds and areas served by ponds within the study area.

3.5.2.2 Sources of Stormwater Pond Geometry Input Data

As indicated previously, WinSLAMM modeling included 52 stormwater management ponds. The Town provided MSA with copies of construction plans for 40 of the stormwater ponds. In most cases these plans were sufficient to fully describe all the input data required by the WinSLAMM model for evaluating ponds. In some cases, information needed to be supplemented either from aerial topographic information or from visual inspection of the stormwater facility. For the remaining 12 stormwater ponds no plan data was available, nor was their sufficient detail available from aerial photographs of topographic mapping to determine critical pond geometry data. The drainage areas for ponds with no available geometric data were assessed in the WinSLAMM models, however the lack of pond data prevented evaluation of TSS and TP reductions achieved by the ponds.

Appendix C provides detailed information describing the geometry of each stormwater detention pond evaluated in the model as well as references to where model input data was obtained.

4.0 APPLICATION OF REGULATORY CONDITIONS TO WINSLAMM INPUT DATA

The standards outlined within NR151 require that regulated communities achieve a 20% reduction in TSS in runoff that enters waters of the state, relative to no controls. A TMDL study for the Wisconsin River is expected to be approved by WDNR and USEPA in 2018. When approved, the Wisconsin River TMDL will assign a “wasteload allocation” for TP in addition to a wasteload allocation for TSS. It is expected that the requirements of the TMDL will exceed the minimum TSS reduction requirement of NR 151.

WDNR has published several model guidance documents which describe the preferred methods for developing modeling studies such as this one which are intended to demonstrate compliance with NR151. The following discussion highlights some important elements of WDNR guidance regarding the application of water quality models for communities regulated by NR151 and NR216 which are located within watersheds with WDNR and EPA-approved Total Maximum Daily Load studies. This guidance is included in a document dated October 20, 2014 from Pam Biersach, Director of the Bureau of Watershed Management and is titled, “TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance.” This memorandum is included in its entirety in Appendix D.

“TMDL Analysis Area

“An MS4 is to include all areas within its corporate boundary unless it is listed as optional. Although the MS4 permit focuses on current areas served by an MS4, it may be appropriate to include future land use planning areas.

> *"…the [Township] needs to include all areas within the most recent urbanized area, adjacent developed and developing areas whose runoff is connected or will connect to their MS4.*
>
> *"Highways: A permitted MS4 owner/operator of a highway needs to account for the pollutants generated within the Right-Of-Way (ROW). An exception would be a roadway crossing over a highway where the owner of the roadway crossing structure is responsible for the pollutants associated with their bridge and approach structure within the lower highway's ROW. WisDOT is responsible for state highways that are not connected highways. A county is responsible for county highways that it maintains.*
>
> *"For reporting purposes, the pollutant reductions must be summarized by TMDL reachshed. Additionally, pollutant loads for grouped drainage areas as modeled shall also be reported.*
>
> *"The additional runoff volume from areas that are outside of the analysis area needs to be accounted for when it drains into treatment devices. The pollutant load can be "turned off" but the runoff hydrology needs to be accounted for to properly calculate the treatment efficiency of the device.*

Map 6 in Appendix A identifies the limits of the study area evaluated in this report and identifies areas excluded from inclusion in pollutant loading and reduction calculations.

Note that the 'exclusion' of pollutant loads from lands outside the limits of the urbanized area, is to be accommodated in the WinSLAMM modeling through use of an 'other device.' Unfortunately, a current limitation of the WinSLAMM model is that other devices are only effective at removing particulate pollutants. This is entirely effective for exclusion of TSS from areas outside the urbanized area, since TSS is by definition particulate; however, Total Phosphorus includes both particulate and dissolved components and so the other device is not completely effective in 'turning off' TP loads from lands outside the urbanized limits. Additionally, since dissolved phosphorus from outside the urbanized area which drain to management practices within the urbanized area, and many practices within the urbanized area rely on infiltration – a practice highly effective at removing dissolved phosphorus – the modeling often reports Total Phosphorus reductions from various practices that include dissolved phosphorus which should have been excluded from calculations. For these reasons, model results reported for TP reductions are not as comprehensively documented so as to avoid confusion in presentation of model output.

The TMDL modeling guidance requires evaluation of pollutant reduction according to TMDL reachsheds. The modeling was completed assuming the Town's urbanized area would be included in one single reachshed, however, as of the date of the modeling completed for this report, the formally selected reachsheds were not available. The modeling completed for this study was completed in a 'grouped fashion' as suggested by the modeling guidance. Specifically, BMPs draining in series to a single outfall were included in a single model. Since these BMPs collectively discharge to a single location, any of these individual models can be aggregated to present results applicable to any particular subwatershed (or reachshed) which will make comparison to required reductions a fairly simple process when such information is available.

It should be noted that this analysis did not attempt to segregate loadings or reductions from WisDOT or County roads within the urbanized area limits. This was done principally because agreements are currently in place which assign maintenance responsibilities for the major detention basins along USH 51 to the Town of Rib Mountain. Transportation corridors such as those which may be owned by WisDOT are evaluated in the model as unique land uses and so the future separation of these areas for separate accounting could be done with little difficulty if and when warranted.

5.0 FINDINGS

Tables 6 and 7 below summarized results of the WinSLAMM modeling across the entire study area. These results reflect TSS and TP reductions achieved by existing stormwater quality practices.

TABLE 6
Town of Rib Mountain Current Total Suspended Solids Reduction Performance

Urbanized Area	**Total Load**		**TSS Removed by Existing BMPs**	
Acres	tons/yr	lbs/ac/yr	tons/yr	%
2,432	283.0	232.7	194.4	68.7%

TABLE 7
Town of Rib Mountain Total Phosphorus Reduction Performance

Urbanized Area	**Total Load**		**TP Removed by Existing BMPs**	
Acres	lbs/yr	lbs/ac/yr	lbs/yr	%
2,432	1608	0.66	1012	62.9%

Appendix F provides a more detailed summary of model output including individual BMP performance.

5.1 VEGETATED SWALE TREATMENT EFFICIENCY

The Town of Rib Mountain's stormwater management system is heavily reliant upon vegetated swale systems. This study evaluated approximately 61 miles of vegetated swales treating runoff from 2,283 acres of the urbanized area. The swales achieve an average TSS reduction efficiency of 63.4% and remove approximately 153 tons of TSS annually, which represents approximately 79% of the total TSS reduction achieved by the entire stormwater management system.

5.2 STRUCTURAL BMP PERFORMANCE

There are 52 stormwater management ponds within the Town's stormwater management system, 40 of which were discretely analyzes in this study. Collectively, these 40 ponds sever 1,182 acres of the urbanized area. The ponds achieve an average TSS reduction efficiency of 51.0% and remove approximately 41 tons of TSS annually, which represents approximately 21% of the total TSS reduction achieved by the entire stormwater management system.

Six of the existing ponds are large regional stormwater ponds that were constructed are part of the reconstruction of USH 51. The individual performance of these ponds are documented in Table 8 below.

TABLE 8
TSS Reduction Performance of Existing Regional Stormwater Ponds

BMP Number	Name	Cumulative Drainage Area	TSS Load	TSS Trapped	TSS Reduction
		(ac)	(tons/yr)	(tons/yr)	(%)
A-100	US51 Pond I	1,337.2	19.3	16.8	87.1%
B-100	US51 Pond H	245.3	14.2	5.7	40.6%
B-110	US51 Pond G	91.6	4.8	3.1	64.7%
C-100	US51 Pond F	226.6	1.2	0.8	62.8%
D-100	US51 Pond E	637.8	9.9	6.8	68.7%
ZZ-100	US51 Pond D	12.6	1.5	1.5	97.5%

Collectively, these ponds trap 34.7 tons of TSS annually, representing 17.9% of the total load trapped by the stormwater management system.

6.0 RECOMMENDATIONS

The findings of this study show that the Town's urbanized area is achieving an average annual TSS reduction of 68.7% and a TP reduction of 62.9% relative to a no controls scenario. The performance level for TSS reduction greatly exceeds the reduction level required by

NR216/NR151; however, it is unknown whether these performance levels will fall short of pollutant reductions (both in TSS and TP) that will be identified in the Wisconsin River TMDL when it is approved.

The following recommendations are presented to position the Town to be in the best position to secure all the modeled reduction levels reported in this document as well as to achieve higher pollutant reduction levels if and when they are required.

1.) **Initiate a Water Quality Trading Program with Town Lands Outside the Urban Area Limits.** WDNR typically allows opportunities for permit holders to trade pollutant reductions with upstream pollutant sources. The Town of Rib Mountain may find itself in a position to trade pollutant reductions with itself since all of the areas excluded from TSS/TP modeling calculations (including loads from USH51) are located within the Town of Rib Mountain. Including the 'unregulated areas' within reduction calculations could provide the Town with another 66.7 tons of TSS reduction and another 533 lbs of TP reduction annually, assuming the same system performance. There may be 'Trade Ratio' penalties applied to these values, however, assuming a 1:1 ratio, this could bring the effective reduction in TSS and TP, relative to regulated loads up to 92.3% and 96.1%, respectively. Immediately upon notification of the Town's wasteload allocation under the Wisconsin River TMDL, the Town should initiate discussion with WDNR regarding the potential for water quality trading of this nature. If reductions beyond those needed for the Town are identified, it may be that the Town could sell these credits to other nearby MS4s, thereby creating an annual revenue stream.

2.) **Secure maintenance agreements for privately owned BMPs.** For the Town to take credit for the pollutant reduction achieved by structural BMPs it will be necessary for the Town to demonstrate that it has the authority to either require private land owners to maintain BMPs on their property or to maintain the management practices directly. The Town should undertake a project to contact property owners with BMPs on their property and enter into long term maintenance agreements with them.

3.) **Investigate Pond Liner Requirements for Wet Detention Ponds.** During the course of the development of this study the Town was informed by the WDNR that the use of stormwater Pond D-100 (USH 51 Pond E) as a regional stormwater pond suitable for providing offsite treatment for a proposed development within the watershed would not be allowed because WDNR review of as-built plans appear to indicate that Pond E is not lined and likely constructed in groundwater and is therefore not in compliance with existing NR 151. WDNR correspondence regarding this pond concludes with the statement that, "Unless modifications are made to Pond E to bring it into compliance with current code, you will be unable to use it meet your TSS requirements." A complete copy of the email containing this discussion is included in Appendix E

Because of the important nature of all the regional ponds serving the USH51 corridor, the Town should undertake a geotechnical study to investigate groundwater elevations as well as the conditions of the bottoms of all ponds serving USH51 to ensure that the ponds may be credited towards the Town's TSS and TP reductions. If investigations find soils below the pond to be unsuitable as liner materials and groundwater elevations above the pond bottom, the Town should implement a plan to install liners in all six regional ponds serving the Town. It is noted that this project may involve multiple jurisdictions.

4.) **Implement a program to require inspection and routine maintenance of structural stormwater management practices.** A fundamental assumption of this study is that each management practice is operating as originally planned. It is an accepted fact that once management practices capture a certain critical volume of TSS, their ability to capture additional TSS is reduced, or is lost altogether. The Town should implement a routine inspection program to ensure that publicly owned BMPs are kept in proper working order. Long Term Maintenance Agreements for privately owned BMPs should require routine, perhaps annual, inspection and reporting requirements.

5.) **Implement a systemic program for measuring infiltration rates within structural BMPs throughout the Town.** This study has shown the significance of the Town's system of grassed swales at removing TSS and TP from stormwater runoff. A large fraction of TSS and TP reduction was achieved by the swales through the process of infiltration (which removes not only particulate pollutants, but also dissolved pollutants). The model-applied infiltration rate was determined by taking the geometric average rate obtained from twenty field tests. The results of these tests included values ranging up to 2.5 times the largest applied geometric average value used in this study.

At the time of the preparation of this report, WDNR is in the process of finalizing guidance documentation regarding infiltration assessments for stormwater practices. It is expected that this document will require the application of reduction factors to measured infiltration rates dependent on the number of infiltration tests conducted (a larger reduction will be required for studies with fewer infiltration tests). Additional infiltration tests will allow for more confident application of infiltration rates throughout the Town and may allow for application of a lower reduction factor at such time as WDNR publishes new infiltration testing guidance.

Infiltration tests should also be conducted within existing infiltration ponds to more confidently estimate infiltration rates in these BMPs as well.

6.) **Conduct BMP topographic surveys.** To conduct the water quality modeling used in this study it was necessary to use alternative data sources to define critical input data for 12 of the 52 existing stormwater detention ponds. Additionally, there were 17 stormwater BMPs were there were no construction plans were available or where plans contained insufficient detail for any level of modeling. Many of the ponds with missing data are located upstream of high-performing regional detention ponds or a within areas served by extensive swale systems; however, there are 12 that are essentially stand-alone BMPs. The estimated TP load to these BMPs is 66.2 lbs/year; which is only 4% of the regulated load, and comparatively small. However, given that a typical life-cycle of a stormwater pond is approximately $450 per pound of phosphorus trapped, the cost to obtain plans or survey and model these existing BMPs is extremely low.

It is recommended that the Town undertake a systemic program to obtain final construction plans or survey ‘as-built’ conditions for all structural BMPs where critical information is lacking so that the actual performance of each BMP can be more accurately estimated (appendices C and F identify BMPs where critical data is lacking).

7.) **Retrofit Existing Water Quality BMPs.** Several of the ponds evaluated in this study had TSS reduction efficiencies less than 60%. Ponds below this level of reduction often represent cost-effective alternatives for water quality retrofits. Table 9 lists pond candidates with both low treatment efficiency, but also high relative pollutant loads, which collectively represent good opportunity for cost-effective retrofits.

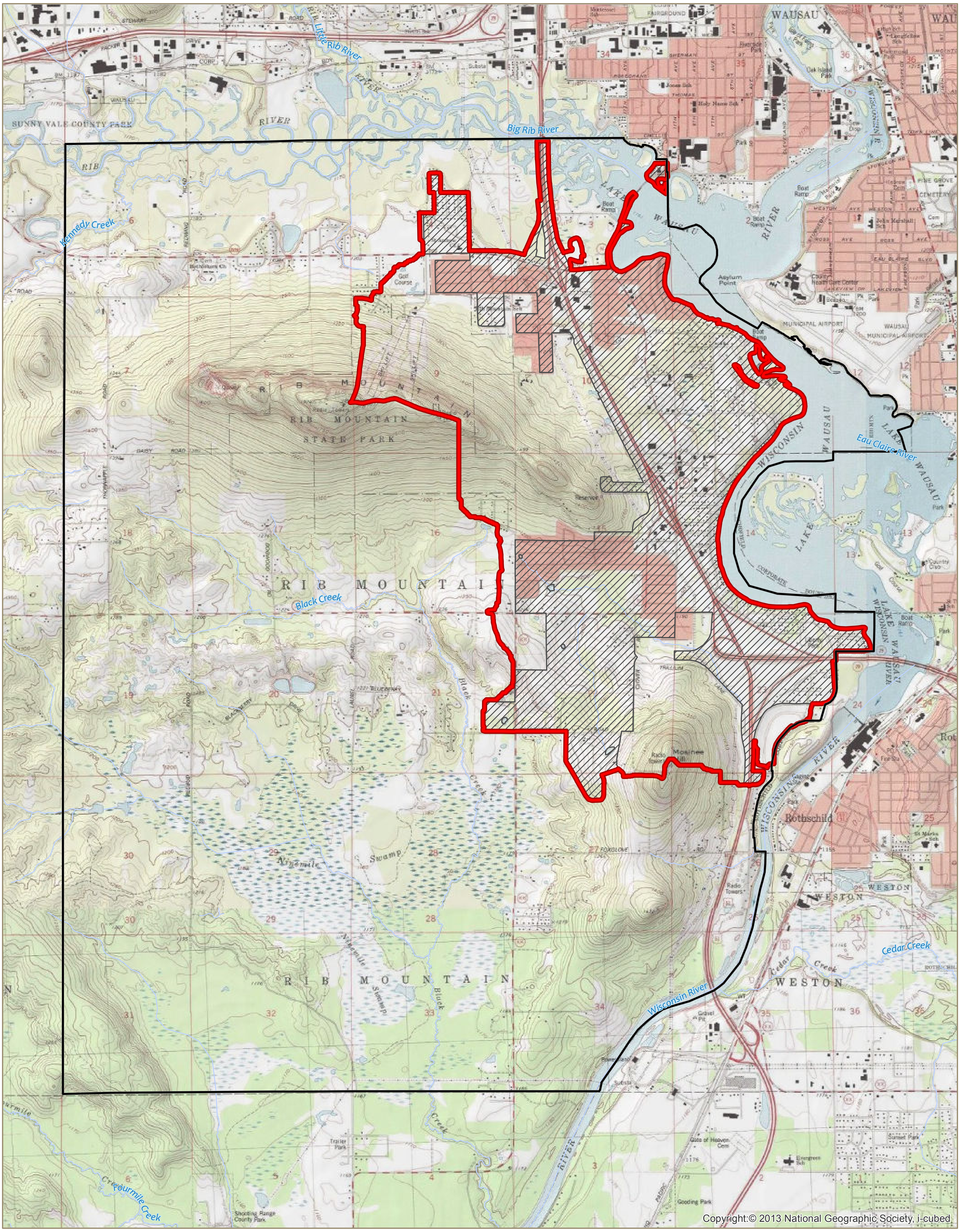
Evaluation of pond retrofits will require additional engineering study to determine the exact nature of improvement necessary to achieve improved pollutant reduction performance.

TABLE 9
Potential Stormwater Ponds for Water Quality Treatment Improvement Retrofits

BMP Number	Name	Existing TSS Reduction	Potential Additional TSS Reduction
		(%)	(tons/yr)
B-100	US51 Pond H	40.6%	5.6
C-100	US51 Pond F	62.8%	0.2
C-110	Freedom Group Pond	33.8%	0.2
D-110	Covantage Regional Pond	38.5%	0.6
I-100	AT&T Pond	52.6%	0.1
P-100	Kohls Pond	38.7%	0.8

APPENDIX A

Maps



MAP 1: STUDY AREA LIMITS

TOWN OF RIB MOUNTAIN
MARATHON COUNTY, WI

Town of Rib Mountain
TMDL Regulated Urban Area
Study Area
River/Stream

DATA SOURCES:
TOWN BOUNDARY PROVIDED BY MARATHON COUNTY.
FLOWLINE PROVIDED BY THE USGS (NHD).
TMDL REGULATED URBAN AREA PROVIDED BY WDNR.
TOPO DERIVED FROM USGS QUADRANGLES.

N

0 750 1,500 3,000 Feet

MSA PROFESSIONAL SERVICES

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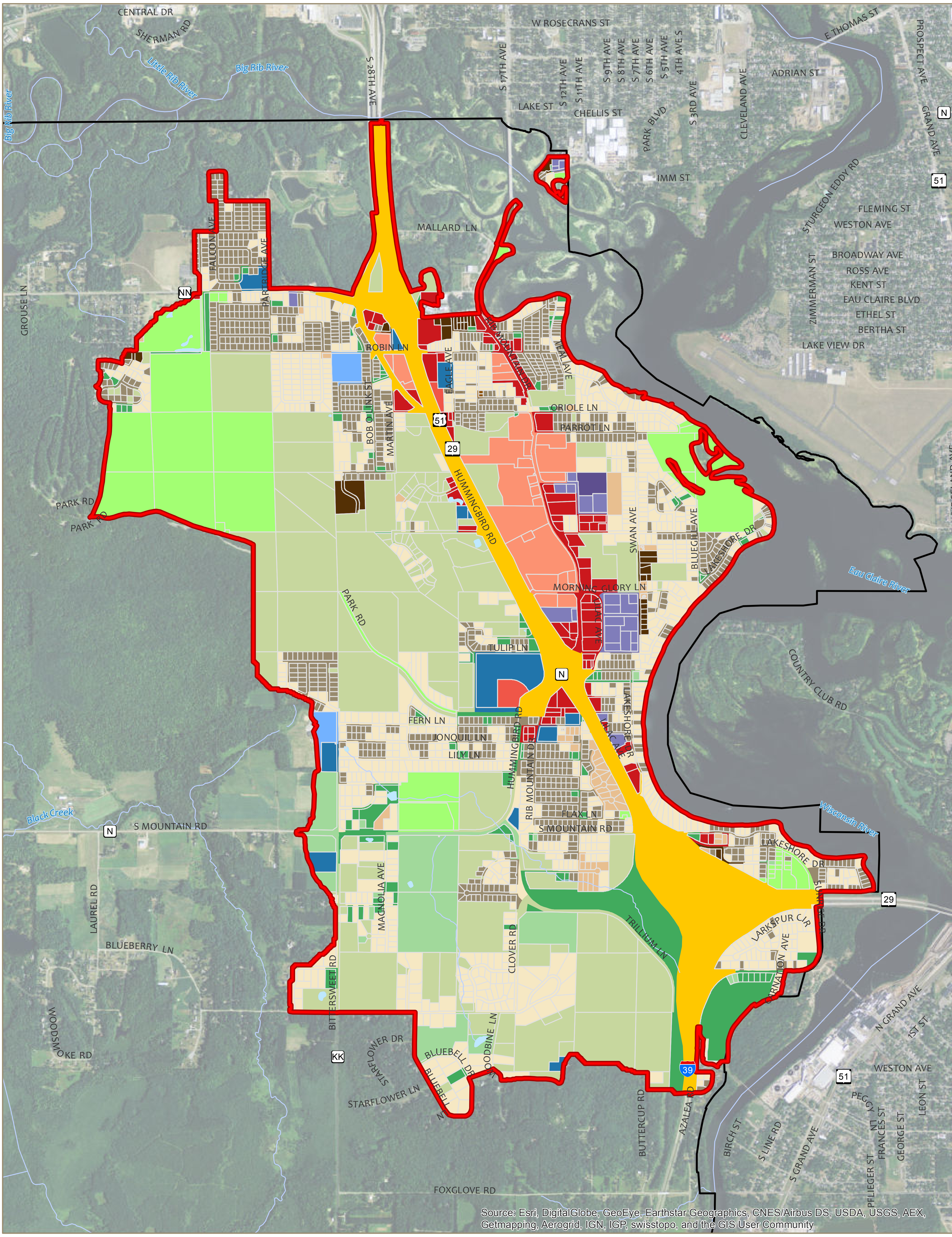

MAP 2: LAND USE

TOWN OF RIB MOUNTAIN
MARATHON COUNTY, WI

Town of Rib Mountain	Residential, Low Density	School	Commercial, Office Park	Open Space
Study Area	Residential, Duplex	Institutional	Commercial, Strip	Water
Parcel	Residential, Medium Density	Light Industrial	Wooded	Highway
River/Stream	Residential, High Density	Medium Industrial	Agricultural	
	Residential, Multi-Family	Commerical, Shopping Center	Park	

DATA SOURCES:
PARCELS AND TOWN BOUNDARY PROVIDED BY MARATHON COUNTY.
FLOWLINE PROVIDED BY THE USGS (NHD).
AERIAL IMAGERY PROVIDED BY ESRI.

N

0 500 1,000 2,000 Feet

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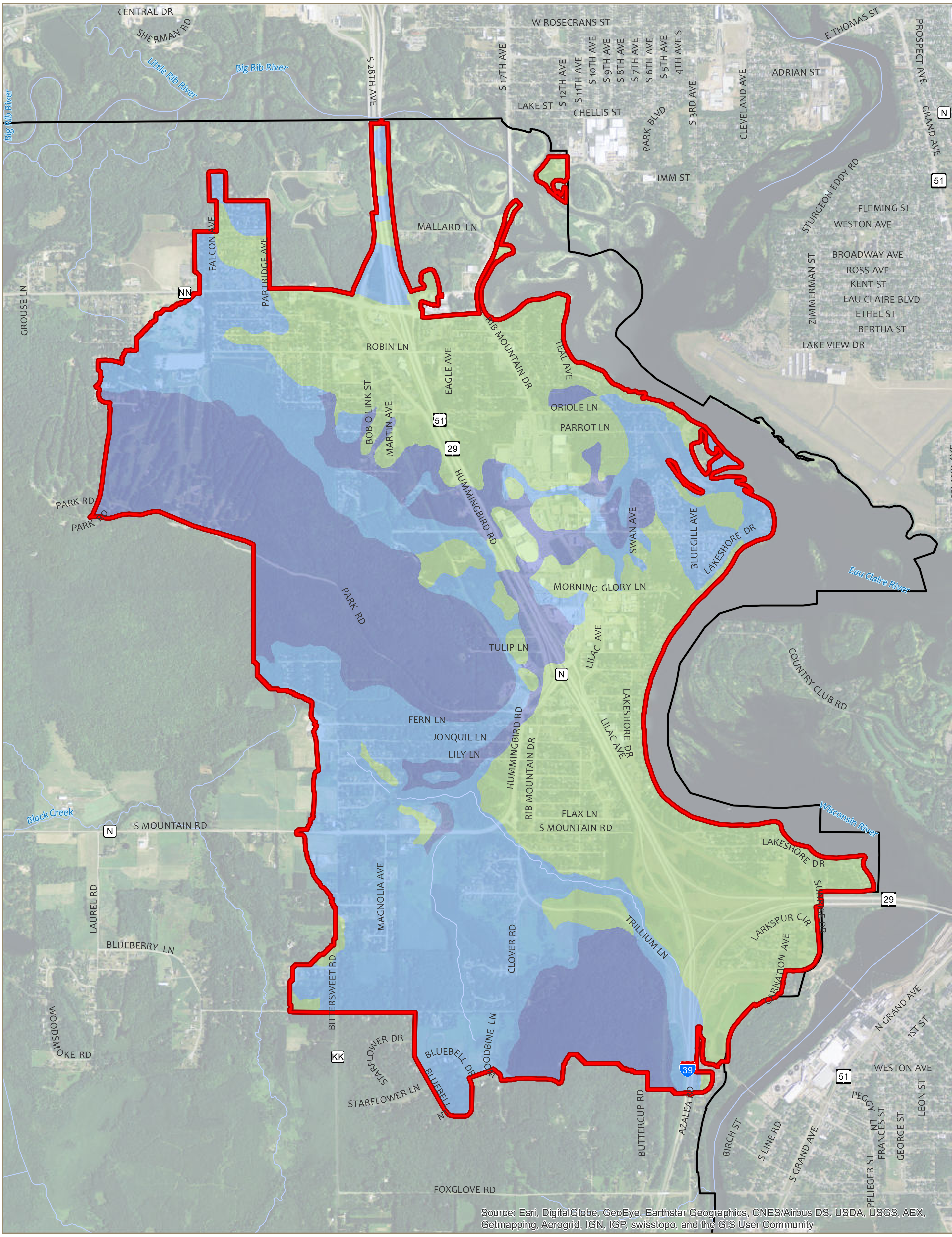

MAP 3: SOILS

TOWN OF RIB MOUNTAIN
MARATHON COUNTY, WI

Town of Rib Mountain
Study Area
River/Stream

Hydrologic Soil Group
- Sand
- Silt
- Clay

DATA SOURCES:
TOWN BOUNDARY PROVIDED BY MARATHON COUNTY.
FLOWLINE PROVIDED BY THE USGS (NHD).
SOILS PROVIDED BY USDA-NRCS (SSURGO).
AERIAL IMAGERY PROVIDED BY ESRI.

N

0 500 1,000 2,000 Feet

MSA PROFESSIONAL SERVICES

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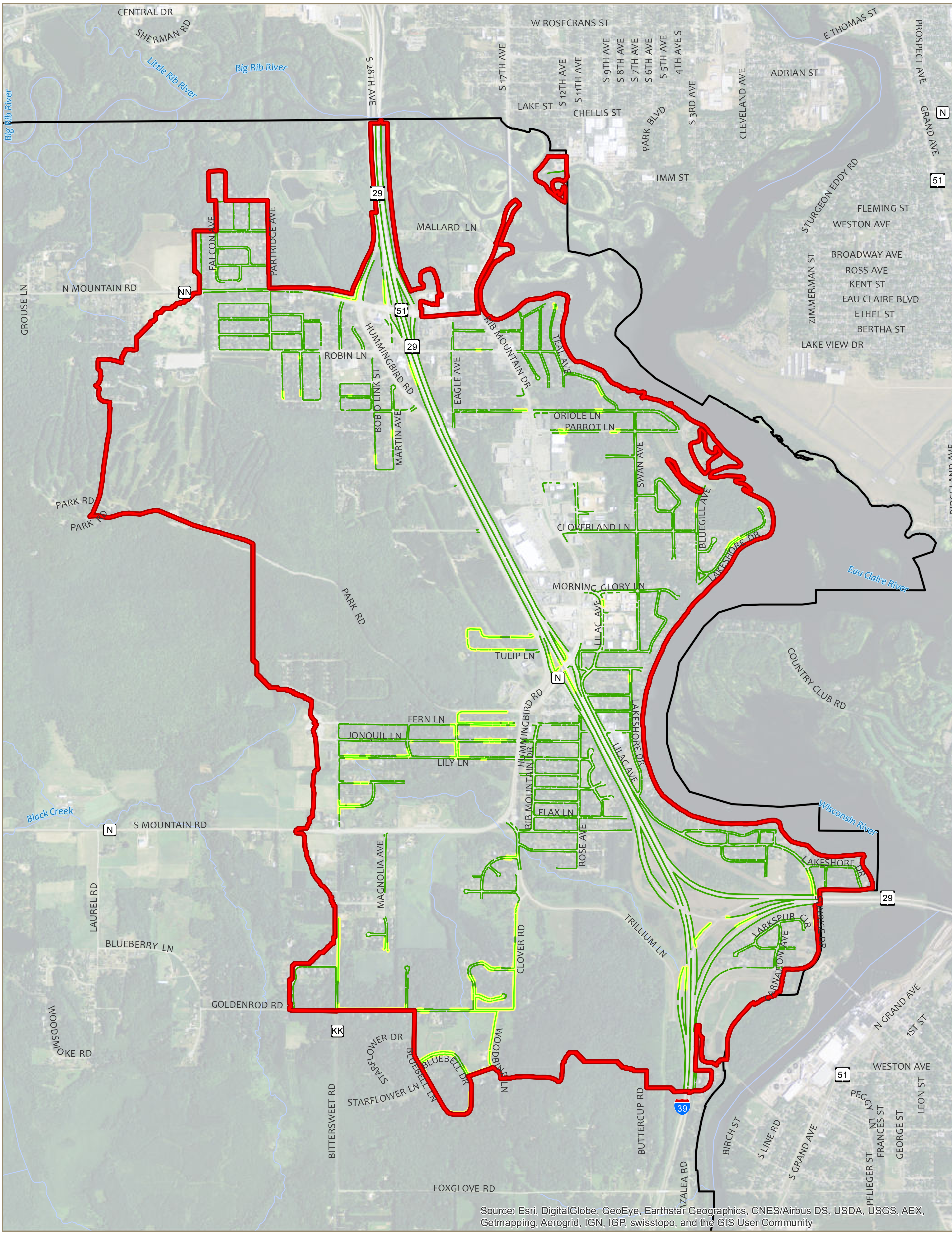

MAP 4: SWALES

TOWN OF RIB MOUNTAIN
MARATHON COUNTY, WI

- Town of Rib Mountain
- Study Area
- River/Stream
- Swale within Urban Area
- Swale within Urban Area where slope > 4%

DATA SOURCES:
TOWN BOUNDARY PROVIDED BY MARATHON COUNTY.
FLOWLINE PROVIDED BY THE USGS (NHD).
SWALES LOCATED WITH AERIAL IMAGERY.
AERIAL IMAGERY PROVIDED BY ESRI.

N

0 500 1,000 2,000 Feet

MSA PROFESSIONAL SERVICES

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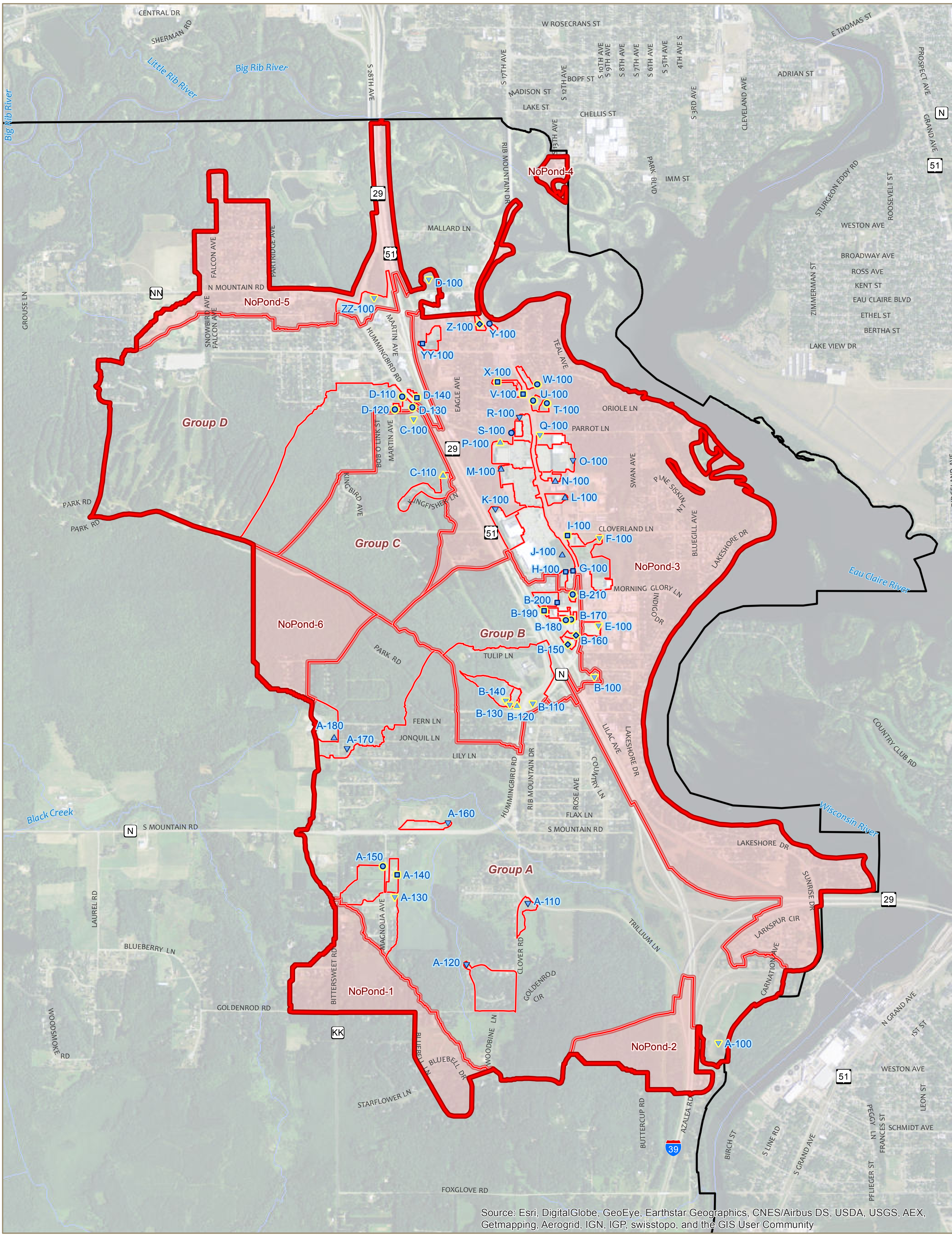

MAP 5: EXISTING STORMWATER PONDS

TOWN OF RIB MOUNTAIN
MARATHON COUNTY, WI

Town of Rib Mountain
River/Stream
Study Area
Subwatershed
Subwatershed Group

BMP Type and Model Status
Dry Pond
Infiltration Basin
Underground/Infiltration
Wet Pond (Shallow)
Wet Pond
Pond was modeled

DATA SOURCES:
TOWN BOUNDARY PROVIDED BY MARATHON COUNTY.
FLOWLINE PROVIDED BY THE USGS (NHD).
AERIAL IMAGERY PROVIDED BY ESRI.

0 500 1,000 2,000 Feet

MSA PROFESSIONAL SERVICES

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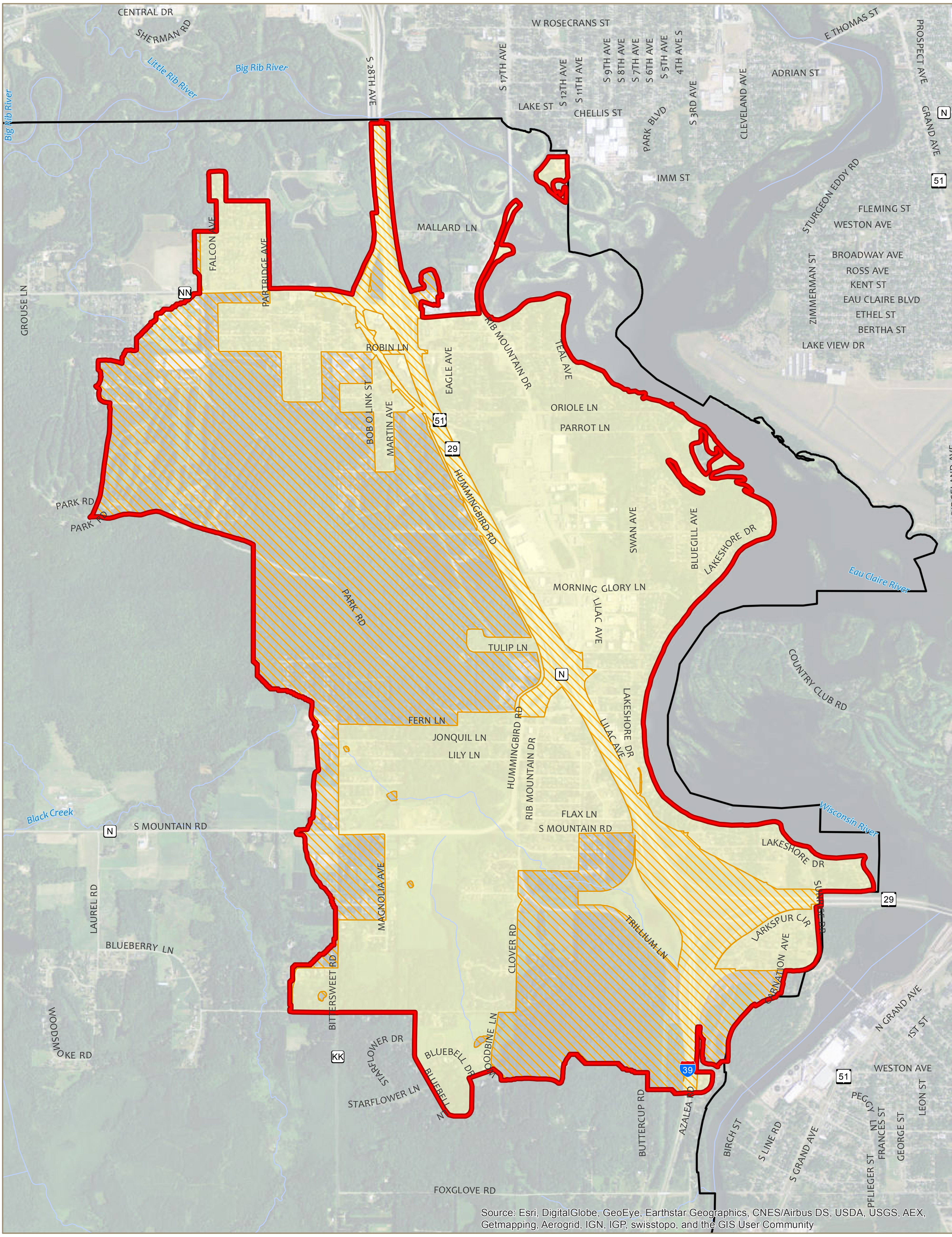

MAP 6: EXCLUDED AREAS

TOWN OF RIB MOUNTAIN
MARATHON COUNTY, WI

Town of Rib Mountain
Study Area
River/Stream
Excluded Area
TMDL Regulated Urban Area

DATA SOURCES:
TOWN BOUNDARY PROVIDED BY MARATHON COUNTY.
FLOWLINE PROVIDED BY THE USGS (NHD).
TMDL REGULATED URBAN AREA PROVIDED BY WDNR.
AERIAL IMAGERY PROVIDED BY ESRI.

0 500 1,000 2,000 Feet

APPENDIX B

Swale Infiltration Rate Assessment

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Memo

To: Town of Rib Mountain

From: Eric J. Thompson, PE, CFM; Sarah Luck, EIT

Subject: Rib Mountain Infiltration Report

Date: July 17, 2015

I. Introduction

This memorandum presents results of the infiltration testing that was conducted at 20 vegetated drainage system (roadside swale) sites in the Town of Rib Mountain, Wisconsin. The purpose of these tests was to determine the static soil infiltration rate for use in development of a WinSLAMM stormwater quality model of the Town's stormwater management system. Infiltration rate refers to the speed at which water penetrates the soil, and is described in this memo in inches per hour (in/hr).

Tests were conducted between May 28, 2015 and June 11, 2015.

II. Methods

Infiltration tests were conducted using a double-ring infiltrometer. A double-ring infiltrometer consists of two concentric metal rings which are partially driven into the ground and filled with water. A photograph of the double-ring infiltrometer apparatus used in this study is shown in the image below.

Double-ring infiltrometer test apparatus with water tank.

Infiltration tests are conducted by observing and recording the drop in water level over an appropriate time interval (5-, 10-, or 20-minute increments in this study) and duration. MSA conducted abbreviated two-hour infiltration tests under saturated conditions as described and endorsed by the Wisconsin Department of Natural Resources (WDNR). Applicable infiltration rates were determined according to the lowest infiltration rate observed during the 2-hour sampling period as prescribed by WDNR ("Errata for Process to Assess and Model Existing Grass Swales (TSS Reduction) Modifications to Double-Ring Infiltrometer Test Procedures in Technical Standard 1002", http://dnr.wi.gov/topic/stormwater/documents/grassswaleserrata.pdf).

III. Results

Table 1 summarizes soil data at each test site along with the observed infiltration rate. The sites and infiltration rates are also plotted in Figure 1 (separate attachment to this memo), and the infiltration plots for the 2-hour sampling period are also attached.

Table 1: Summary of soil data and observed infiltration rates

Site number and street	Hydrologic Soil Group (HSG)*	Underlying soil texture*	Observed minimum infiltration rate (in/hr)
1 – Falcon Way	A	Loamy Sand	1.50
2 – Falcon Ave	B	Sandy Loam	0.84
3 – Blue Jay Lane	B	Sandy Loam	1.44
4 – Quail Ave	A	Loamy Sand	0.48
5 – Eagle Ave	A	Loamy Sand	0.63
6 – Heron Ave	A	Loamy Sand	0.45
7 – Pintail Lane	A	Loamy Sand	0.54
8 – Swan Ave	A	Loamy Sand	0.24
9 – Cloverland Lane	B	Sandy Loam	0.42
10 – Swan Ave	B	Sandy Loam	1.62
11 – Dahlia Lane	A	Loamy Sand	1.44
12 – Jonquil Lane	A	Loamy Sand	0.90
13 – Jonquil Lane	B	Loam	0.24
14 – Jonquil Lane	B	Silt Loam	0.12
15 – S. Mountain Rd	A	Loamy Sand	0.24
16 – Trillium Lane	A	Sandy Loam	0.72
17 – Moonlite Ave	A	Loamy Sand	0.72
18 – Snowdrop Lane	A	Loamy Sand	1.08
19 – Goldenrod Rd	B	Silt Loam	0.24
20 – Bluebell Dr	B	Silt Loam	1.14

**As determined by USDA NRCS*

IV. Discussion

WDNR requires calculation of the geographic mean of observed infiltration rates across a study area to determine the “average” infiltration rate which is to be applied for a modeling study. Because the study area covered a large geographic area which included a wide range of soil types and observed infiltration rates, MSA did not feel it was appropriate to apply an average infiltration rate across the entire Town. Instead we investigated the suitability of applying infiltration rates throughout the study area according to soil characteristics. Table 2 presents a summary of infiltration rates observed by hydrologic grouping and soil texture.

Table 2: Summary of infiltration rates observed by hydrologic grouping and soil texture

			Range of observed minimum infiltration rates (in/hr)	
Hydrologic Soil Group (HSG)	Texture	Number of samples	Maximum	Minimum
A	Loamy sand	11	1.50	0.24
A	Sandy Loam	1	0.72	0.72
B	Sandy loam	4	1.62	0.42
B	Silt loam	3	1.14	0.12
B	Loam	1	0.24	0.24

Table 3 below summarizes the findings based on soil texture and compares them to infiltration rates reported in the Wisconsin Department of Natural Resources (WDNR) Conservation Practice Standards Site Evaluation for Stormwater Infiltration (1002) document (http://dnr.wi.gov/topic/stormwater/documents/dnr1002-infiltration.pdf).

Table 3: Summary of mean infiltration rates observed by soil texture

Soil texture	Number of samples	Observed Geometric Mean Infiltration Rate (in/hr)	*WDNR Design Infiltration Rate Without Measurement (in/hr)**
Loamy sand	11	0.63	*1.63*
Sandy loam	5	0.90	*0.50*
Loam	1	0.24	*0.24*
Silt Loam	3	0.32	*0.13*

**Source: Wisconsin Department of Natural Resources Conservation Practice Standards Site Evaluation for Stormwater Infiltration (1002) bulletin.*

As the table above demonstrates, the observed values do not track well with the WDNR standard infiltration values; specifically, the observation that Sandy loam soils have a higher observed infiltration rate than Loamy sand is incongruous with what the WDNR document indicates.

In an attempt to achieve better correlation between observed and published data, a second soil attribute considered for assessment was hydrologic soil group. Table 4 presents the analysis results.

Table 4: Summary of mean infiltration rates observed by hydrologic soil group

Hydrologic Soil Group (HSG)	Number of samples	Observed Geometric Mean Infiltration Rate (in/hr)
A	12	0.64
B	8	0.53
C	0	NA
D	0	NA

Since there are several soil textures within both HSG A and HSG B classifications, averaging across the larger sample set dampens outlier values and presents a behavior more in line with expectations.

When considering the entire study area, most soils are within HSG A (57%) and HSG B (36%). A small portion of the study area contains HSG C soils (7%). While there were no field tests completed in these areas, a conservative approach is to use the lowest observed infiltration rate across all samples, which is 0.12 in/hr. Note that there were no swales in the Town of Rib Mountain on HSG D soils.

V. Recommendations

For purposes of the Rib Mountain Water Quality Master Plan we recommend using infiltration rates of 0.64 in/hr for HSG A soils, 0.53 in/hr for HSG B soils, and 0.12 in/hr for HSG C soils.

Attachments: Figure 1 – Location of Infiltration Test Sites
Figure 2 – Soils by Hydrologic Soil Group
Individual Infiltration Test Data

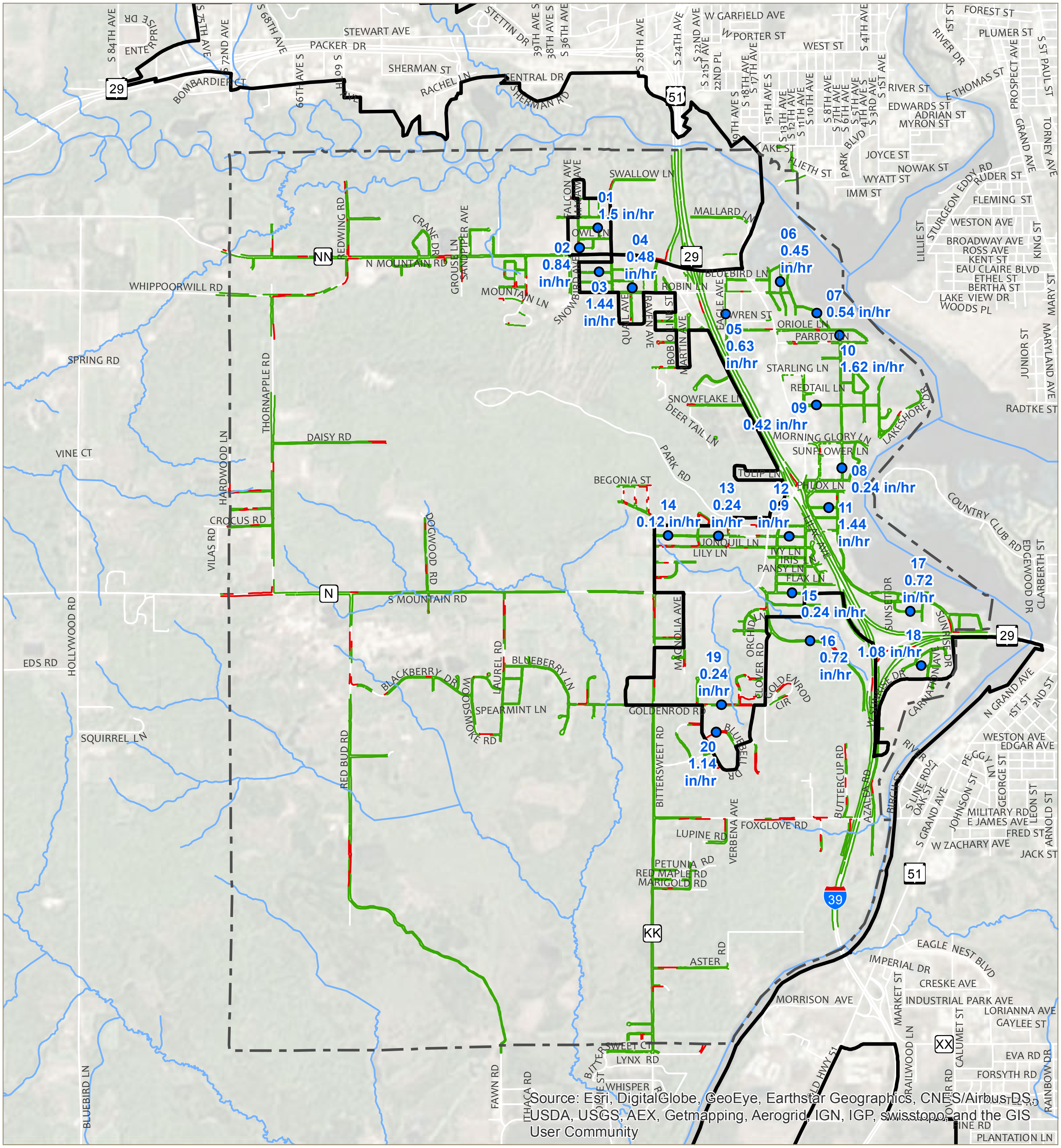

Figure 1 – Location of Infiltration Test Sites

TOWN OF RIB MOUNTAIN
MARATHON COUNTY, WI

Town of Rib Mountain
Urban Area (Census 2010)
River/Stream

Swales
0 - 4%
Greater than 4%

Soil Texture
Loamy Sand
Sandy Loam
Loam
Silt Loam
Muck

Infiltration Test Site

DATA SOURCES:
SWALES DIGITIZED BASED ON AERIAL IMAGERY, WITH EACH SEGMENT OF SWALE BROKEN INTO 500-FT SEGEMENTS OR LESS.
SWALE SLOPES BASED ON 2-FT CONTOURS PROVIDED BY THE TOWN.

0 750 1,500 3,000 Feet

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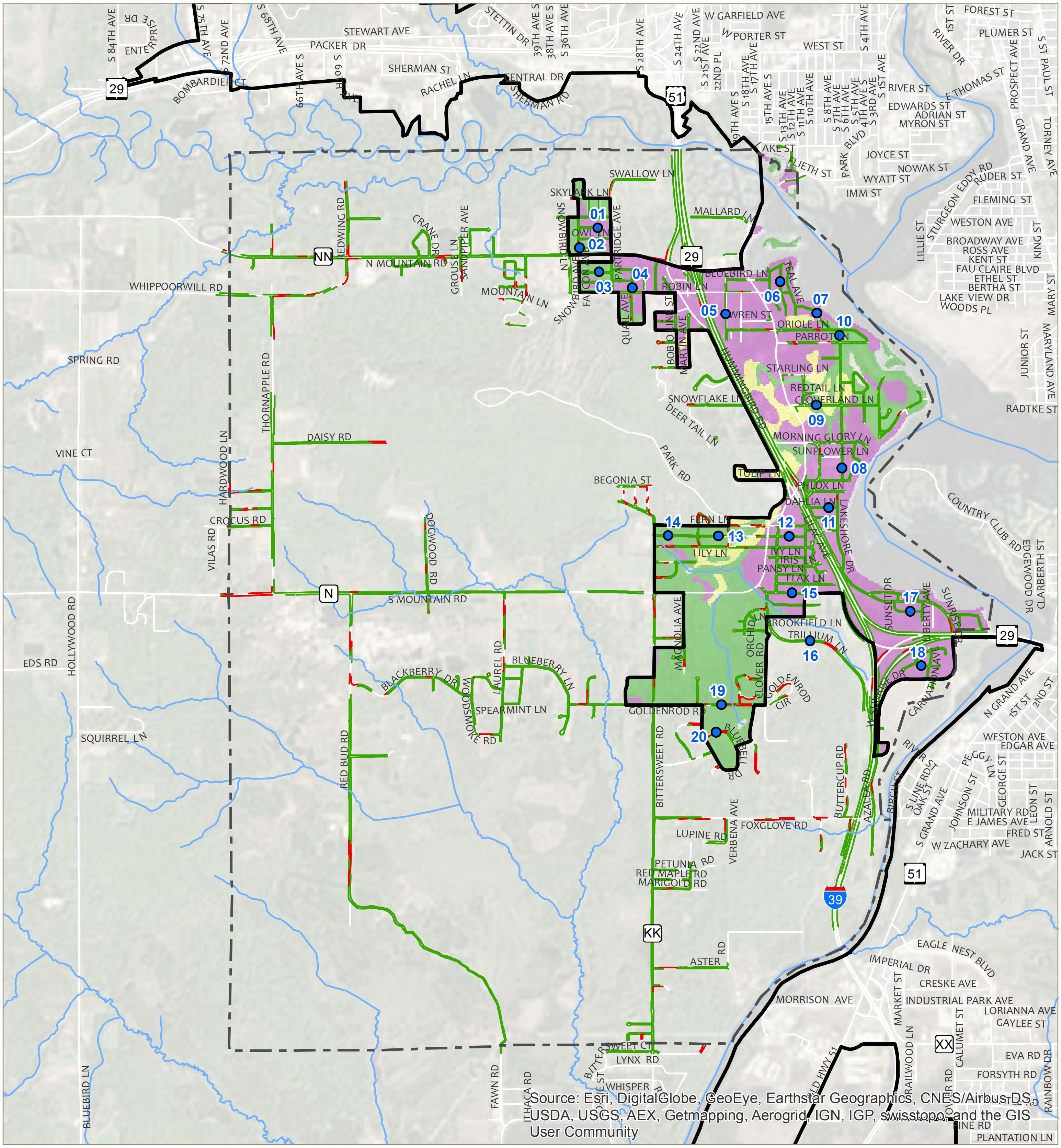

Figure 2 – Soils by Hydrologic Soil Group

TOWN OF RIB MOUNTAIN
MARATHON COUNTY, WI

Town of Rib Mountain

Urban Area (Census 2010)

River/Stream

Swales

0 - 4%

Greater than 4%

Infiltration Test Site

Hydrologic Soil Group

A

B

C

D

DATA SOURCES:
SWALES DIGITIZED BASED ON AERIAL IMAGERY, WITH EACH SEGMENT OF SWALE BROKEN INTO 500-FT SEGEMENTS OR LESS.
SWALE SLOPES BASED ON 2-FT CONTOURS PROVIDED BY THE TOWN.

0 750 1,500 3,000 Feet

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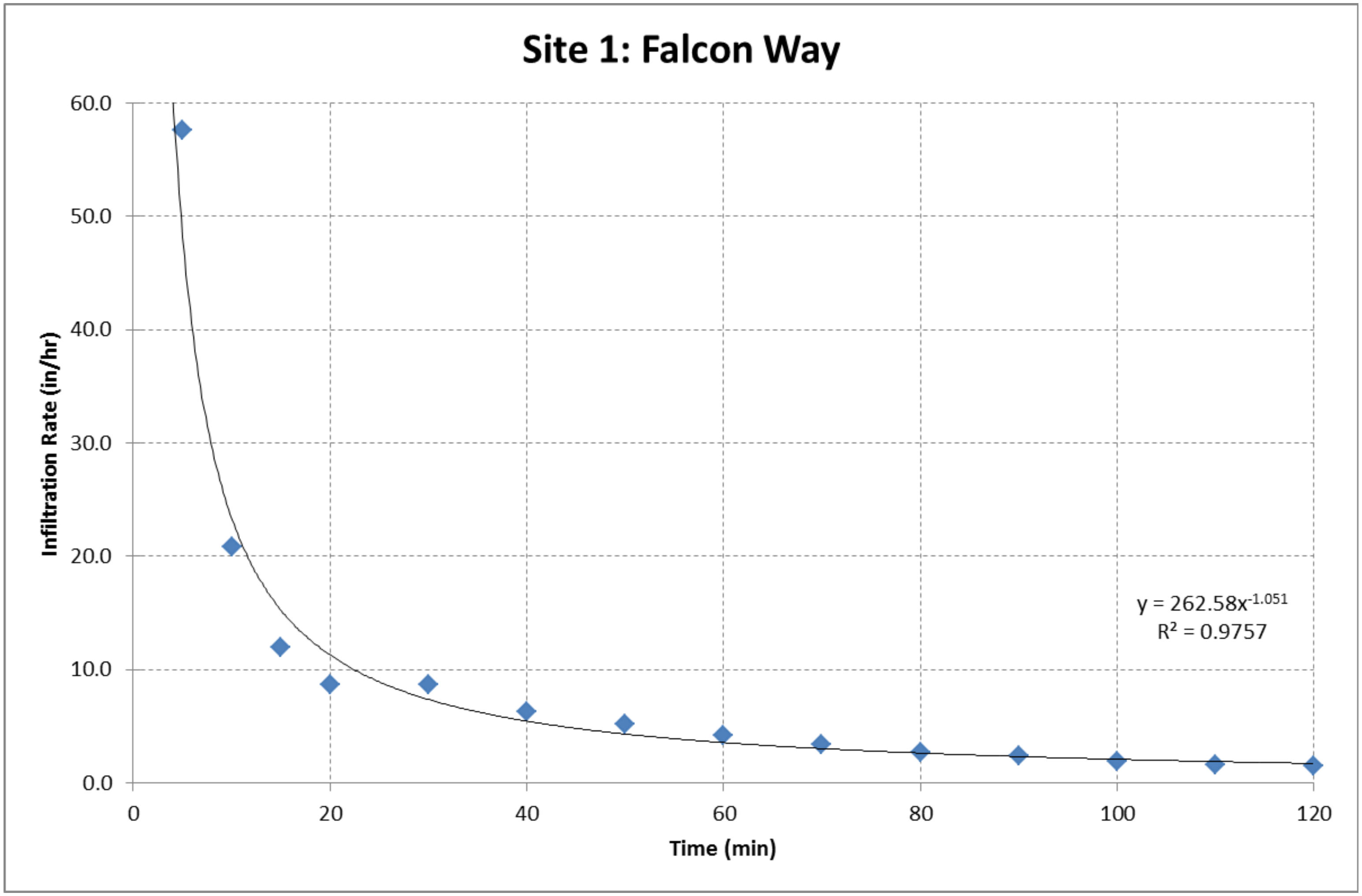
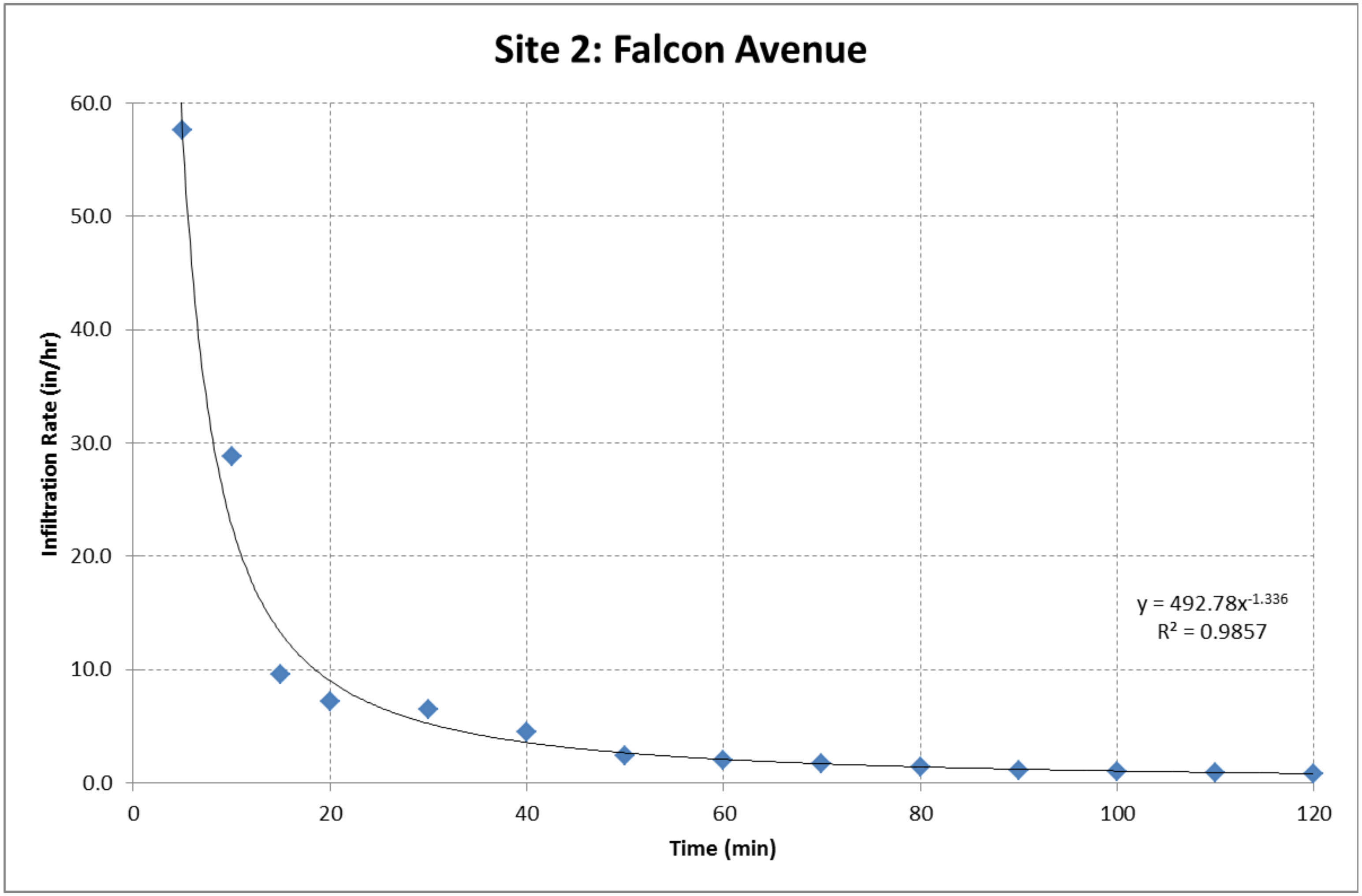
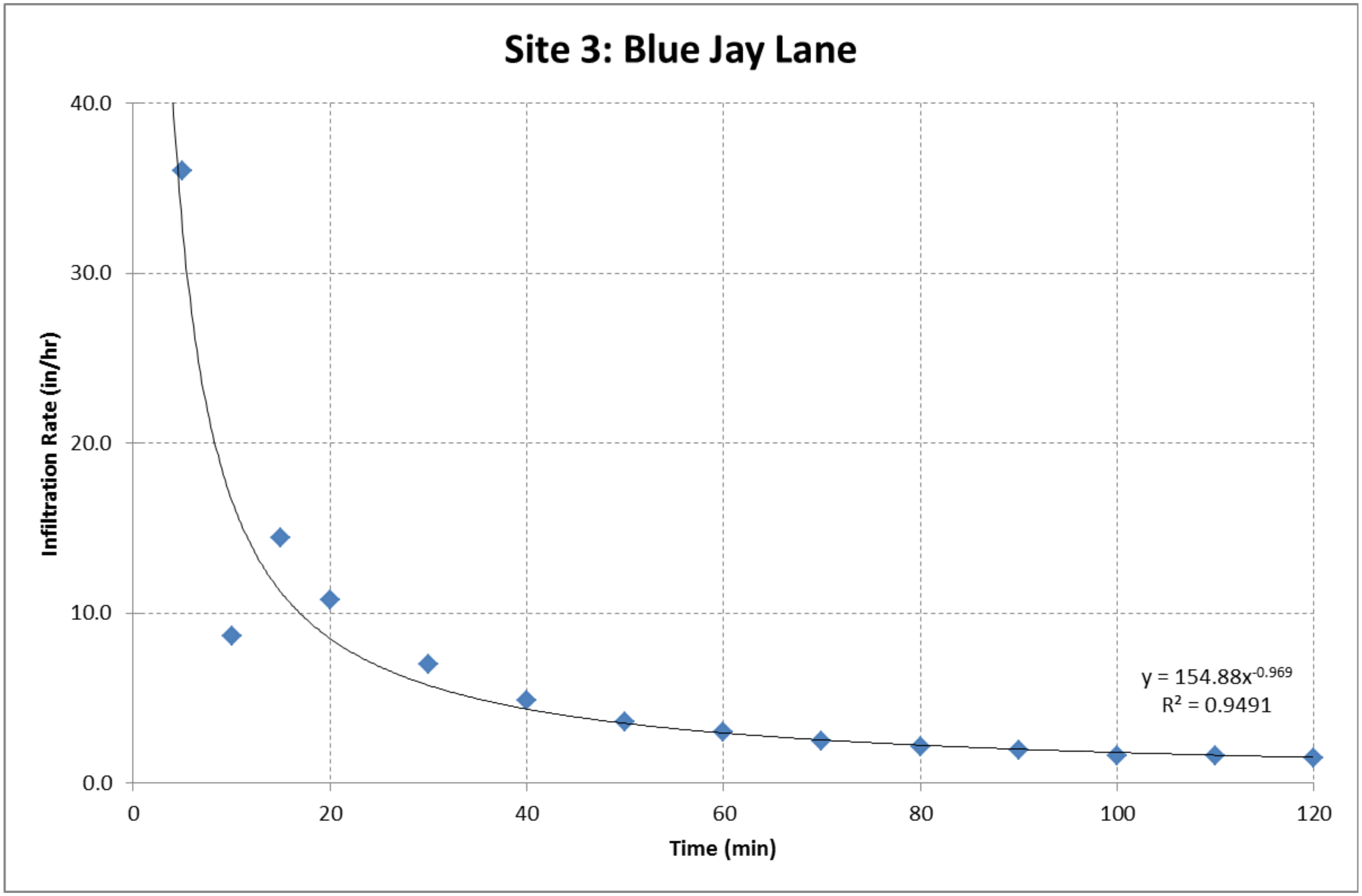
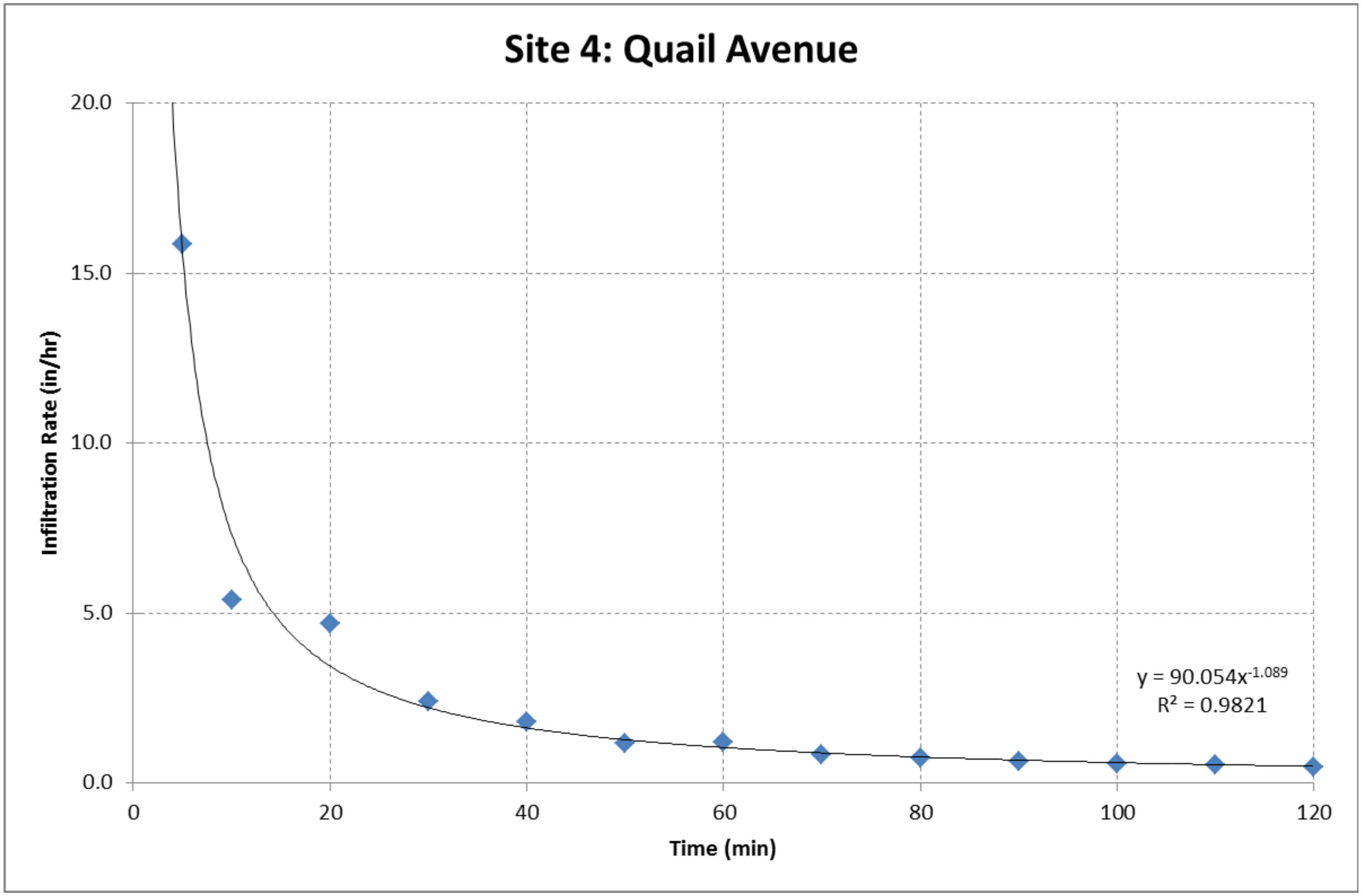
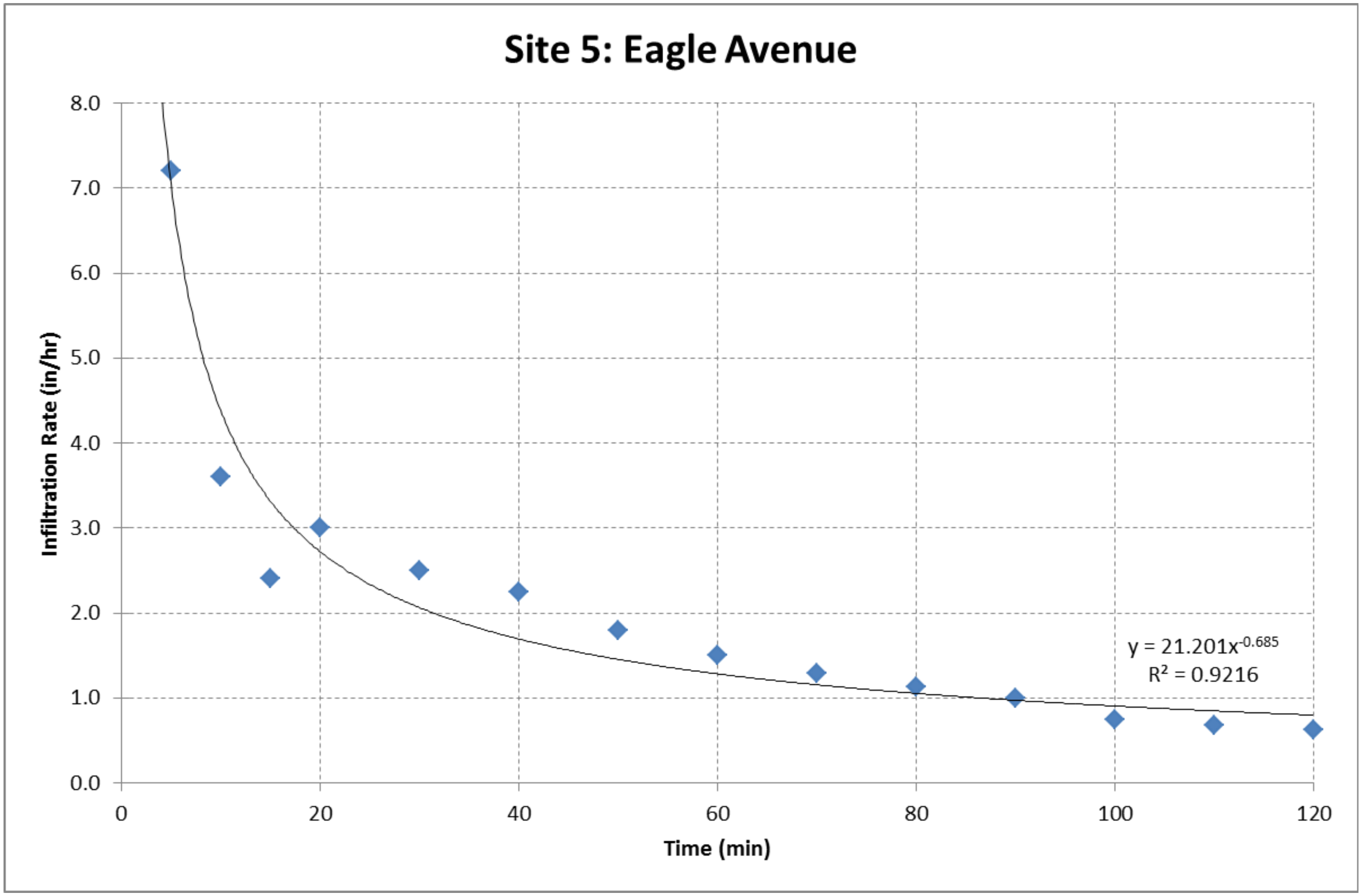
Individual Infiltration Test Data


Site 1: Falcon Way
Infiltration Rate (in/hr)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 262.58x^-1.051
R² = 0.9757

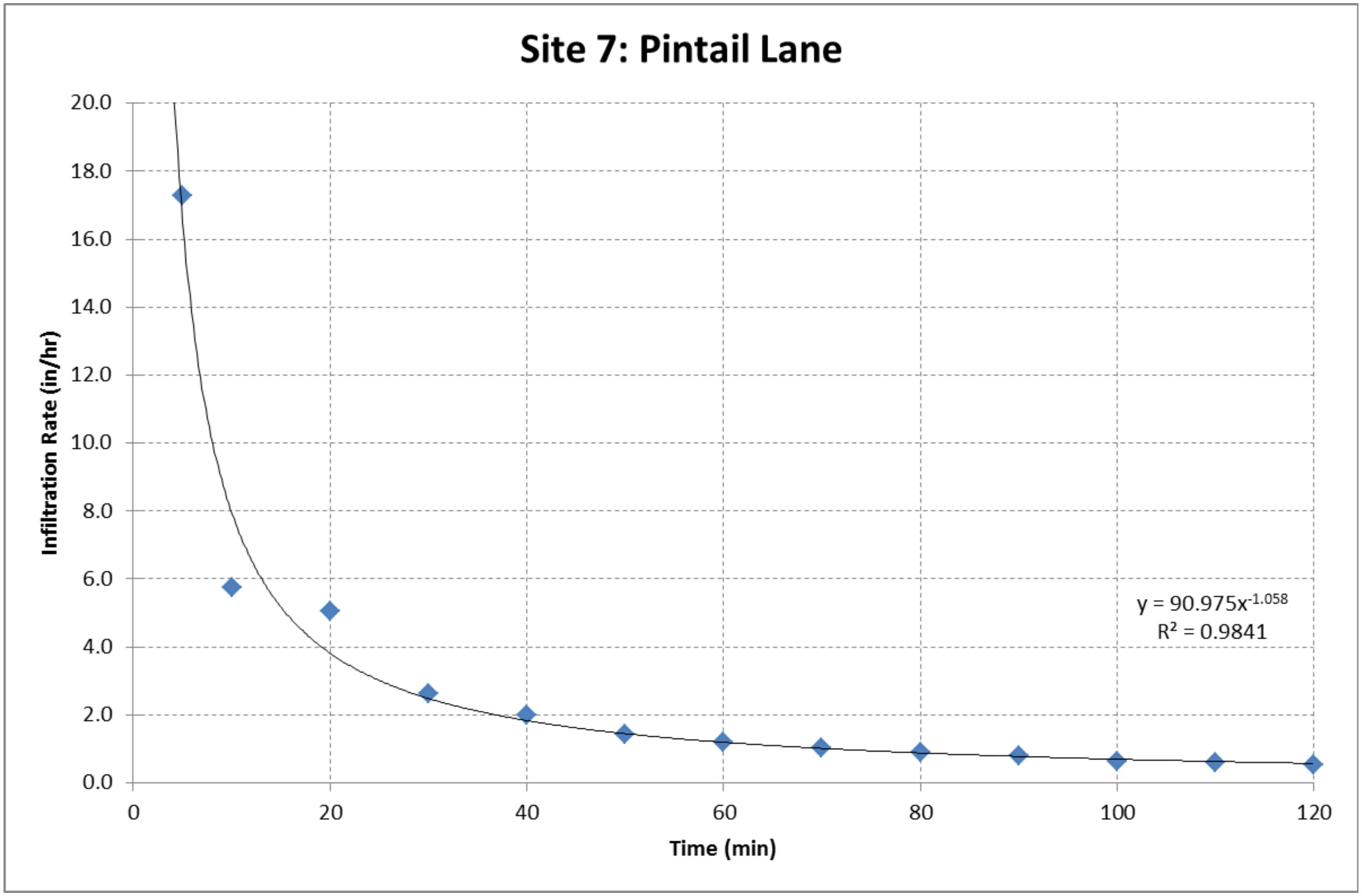

Site 2: Falcon Avenue
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Infiltration Rate (in/hr)
0
20
40
60
80
100
120
Time (min)
y = 492.78x^-1.336
R² = 0.9857


Site 3: Blue Jay Lane
Infiltration Rate (in/hr)
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 154.88x-0.969
R² = 0.9491

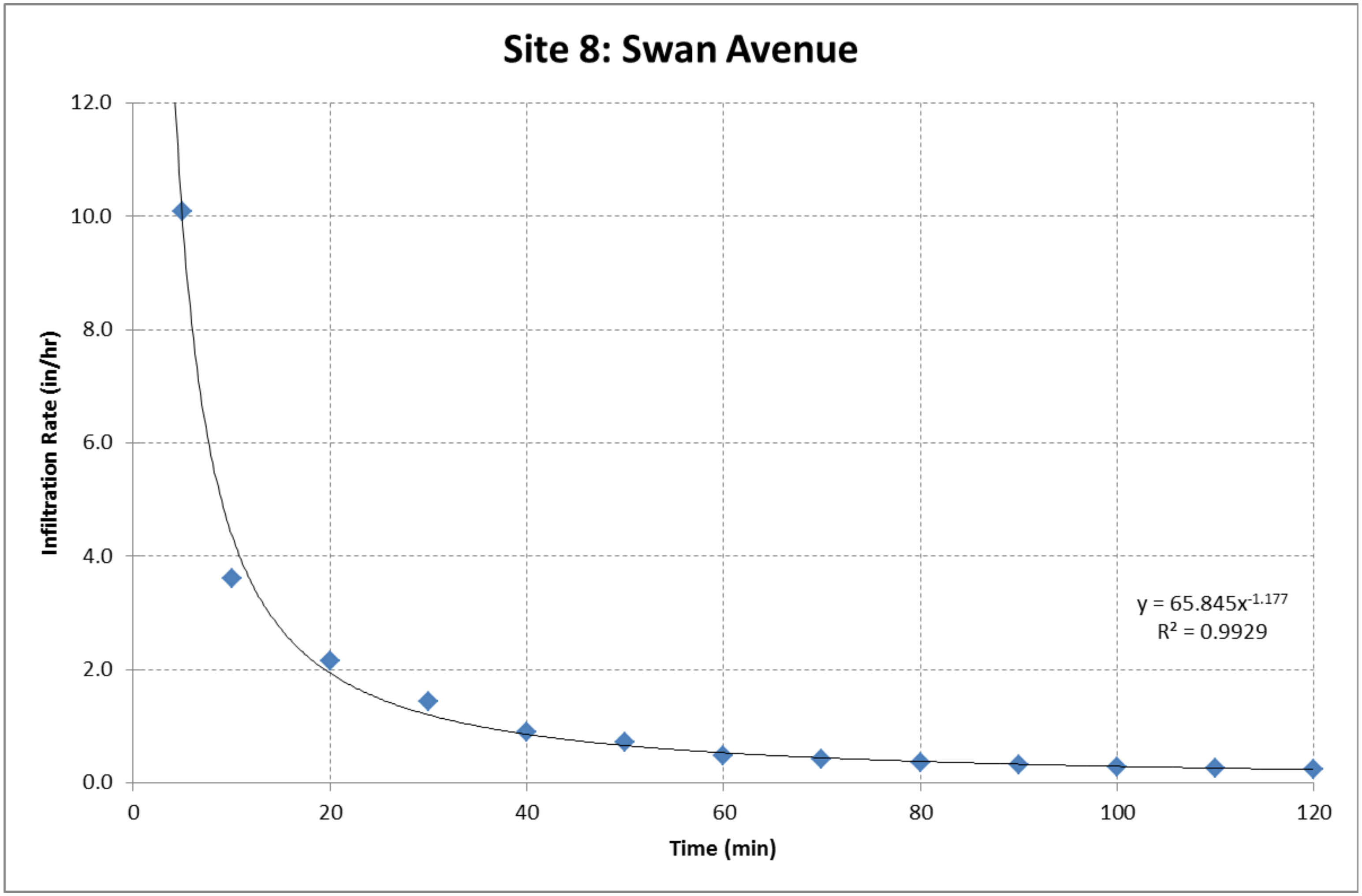

Site 4: Quail Avenue
Infiltration Rate (in/hr)
20.0
15.0
10.0
5.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 90.054x^-1.089
R² = 0.9821

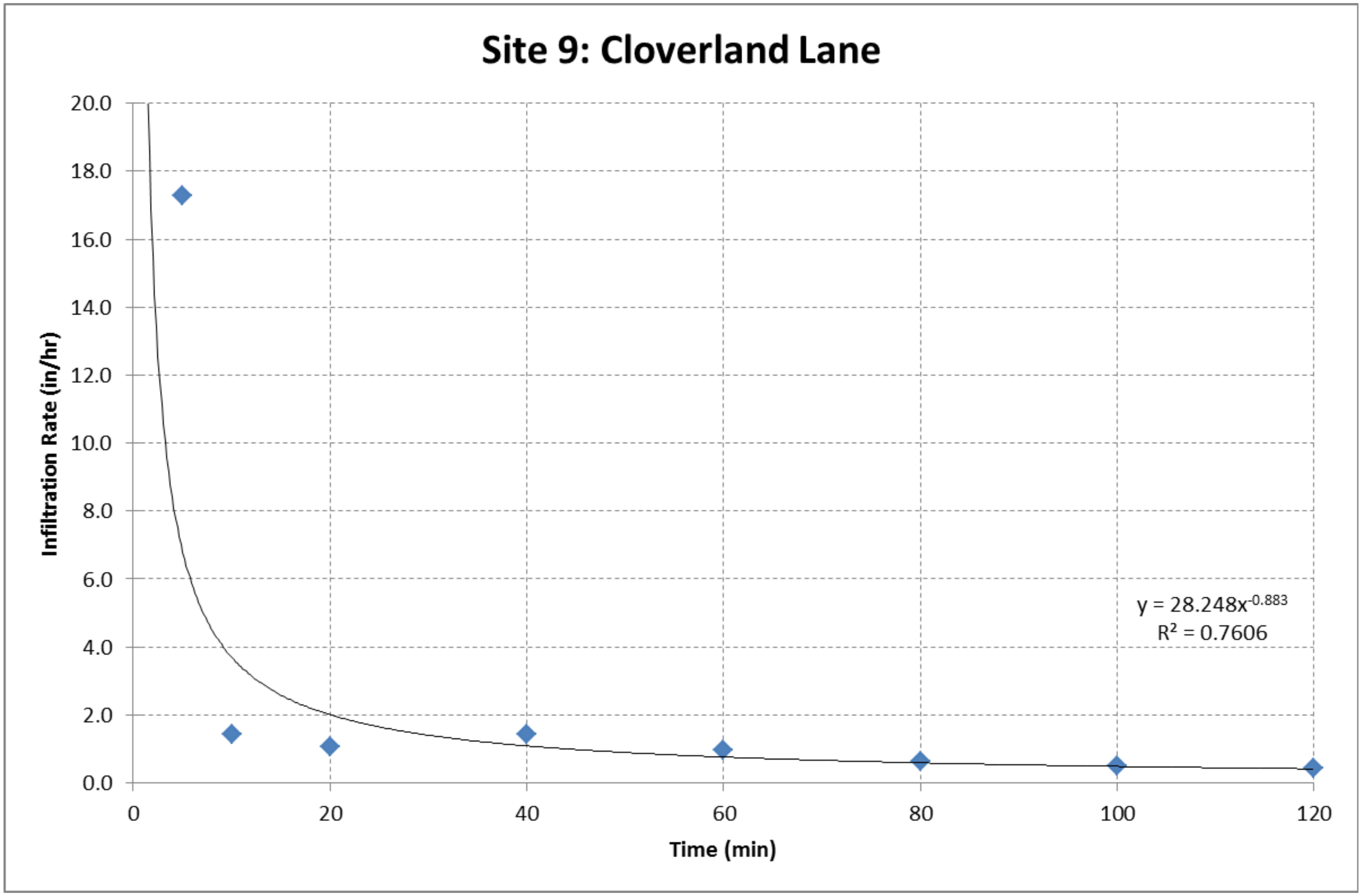

Site 5: Eagle Avenue
Infiltration Rate (in/hr)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 21.201x^-0.685
R² = 0.9216

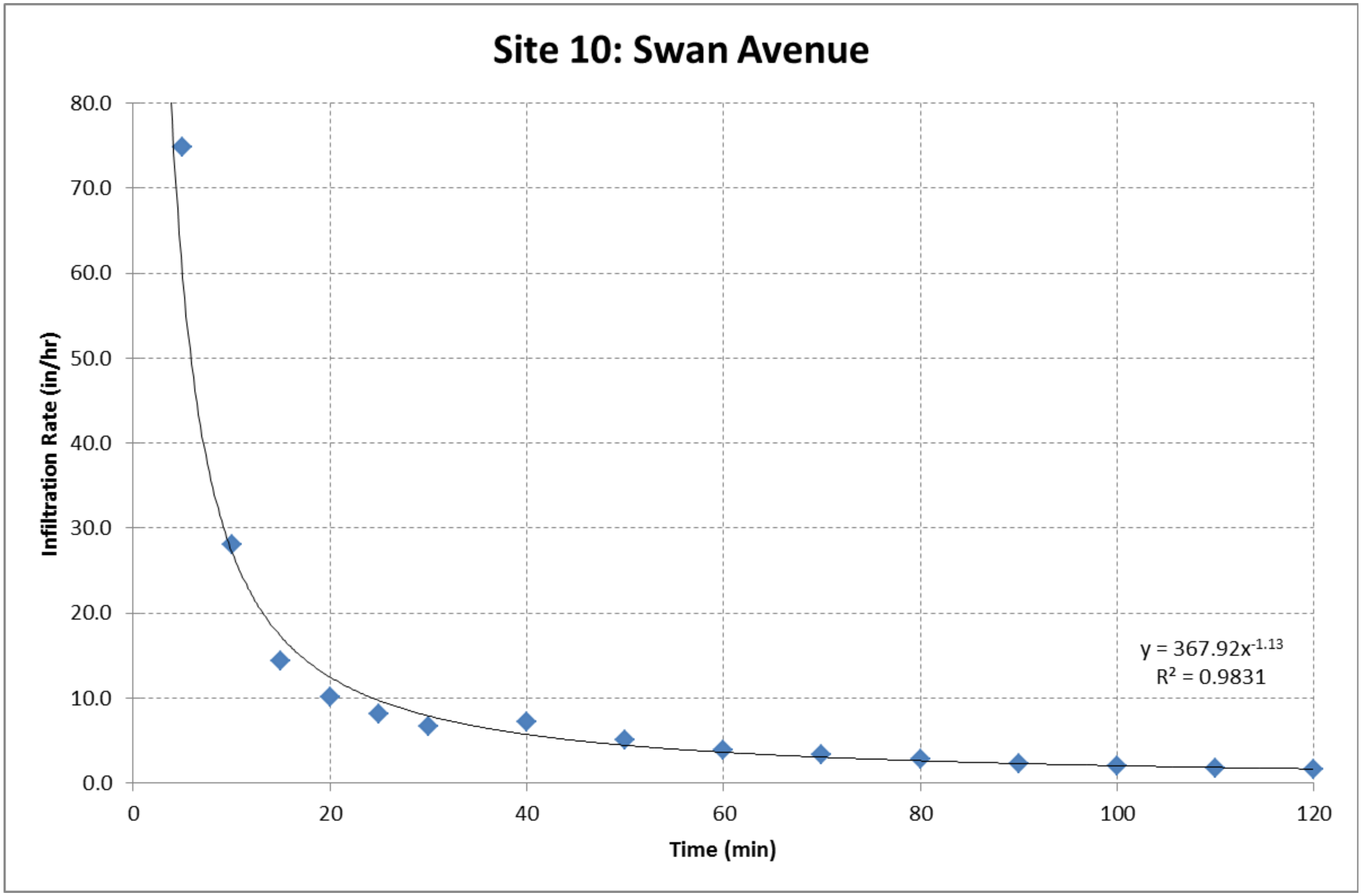
Site 6: Heron Avenue
Infiltration Rate (in/hr)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 103.99x^-1.104
R² = 0.9473



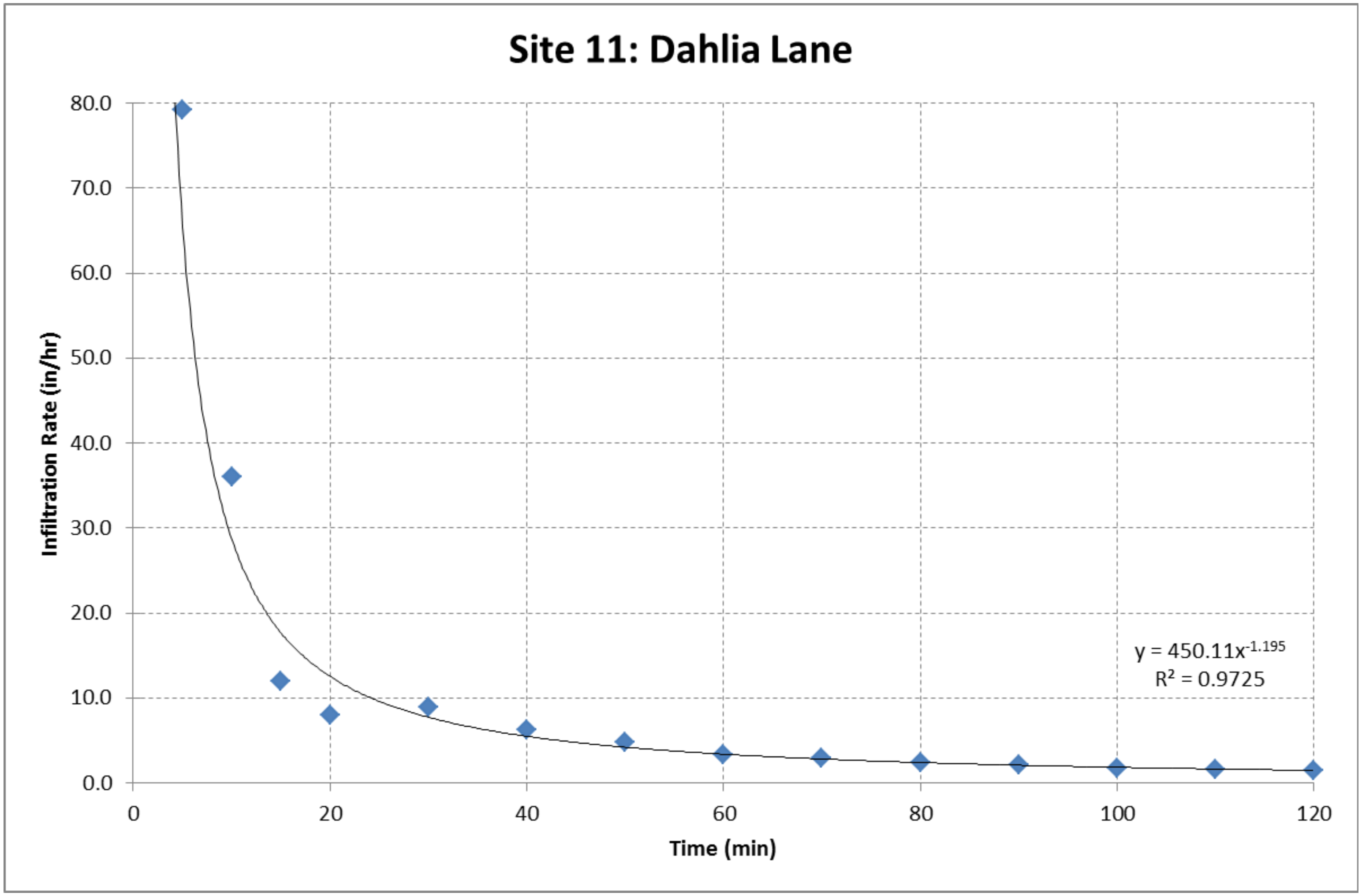
Site 7: Pintail Lane
Infiltration Rate (in/hr)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 90.975x^-1.058
R² = 0.9841

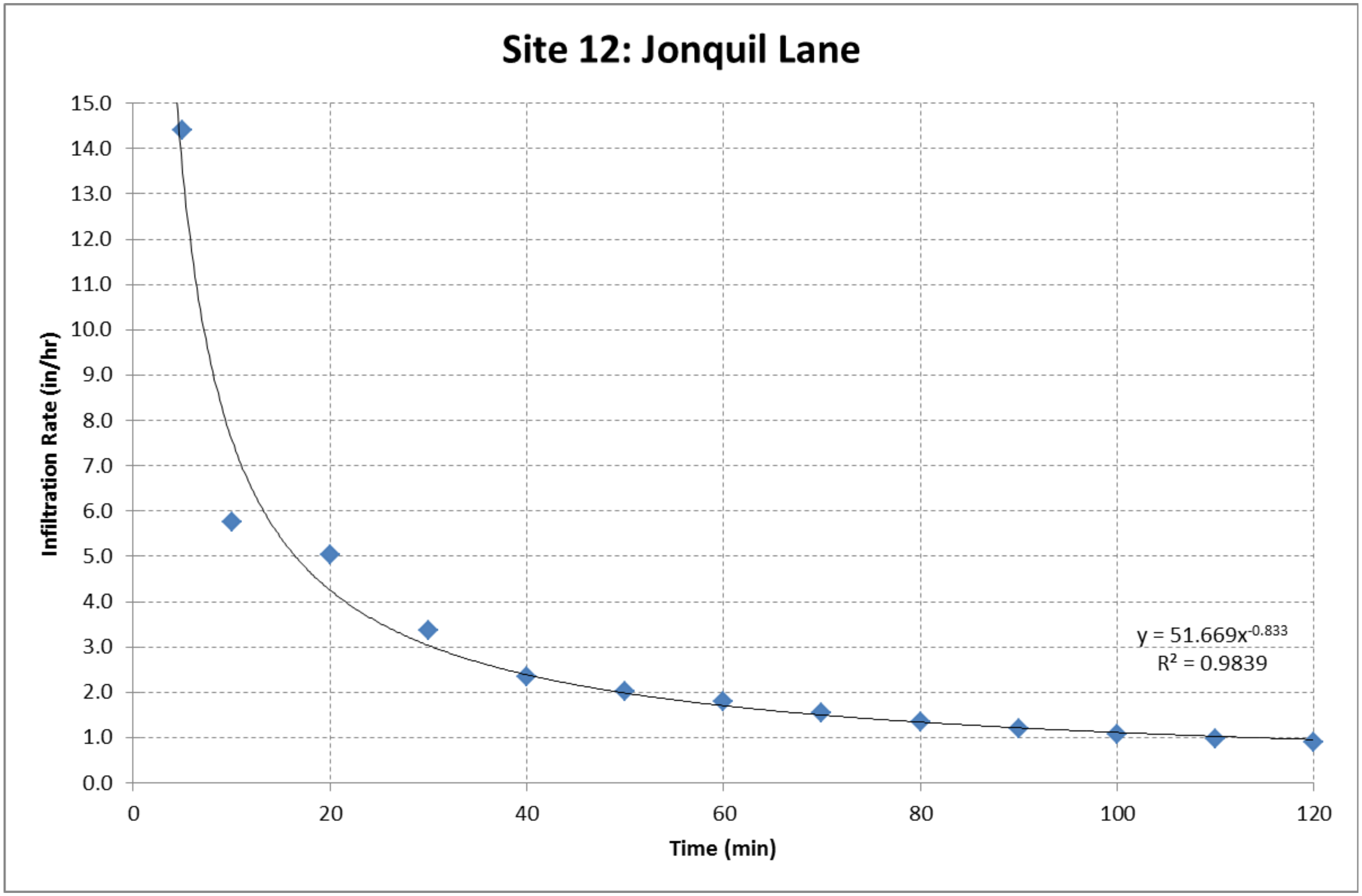

Site 8: Swan Avenue
Infiltration Rate (in/hr)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 65.845x^-1.177
R² = 0.9929

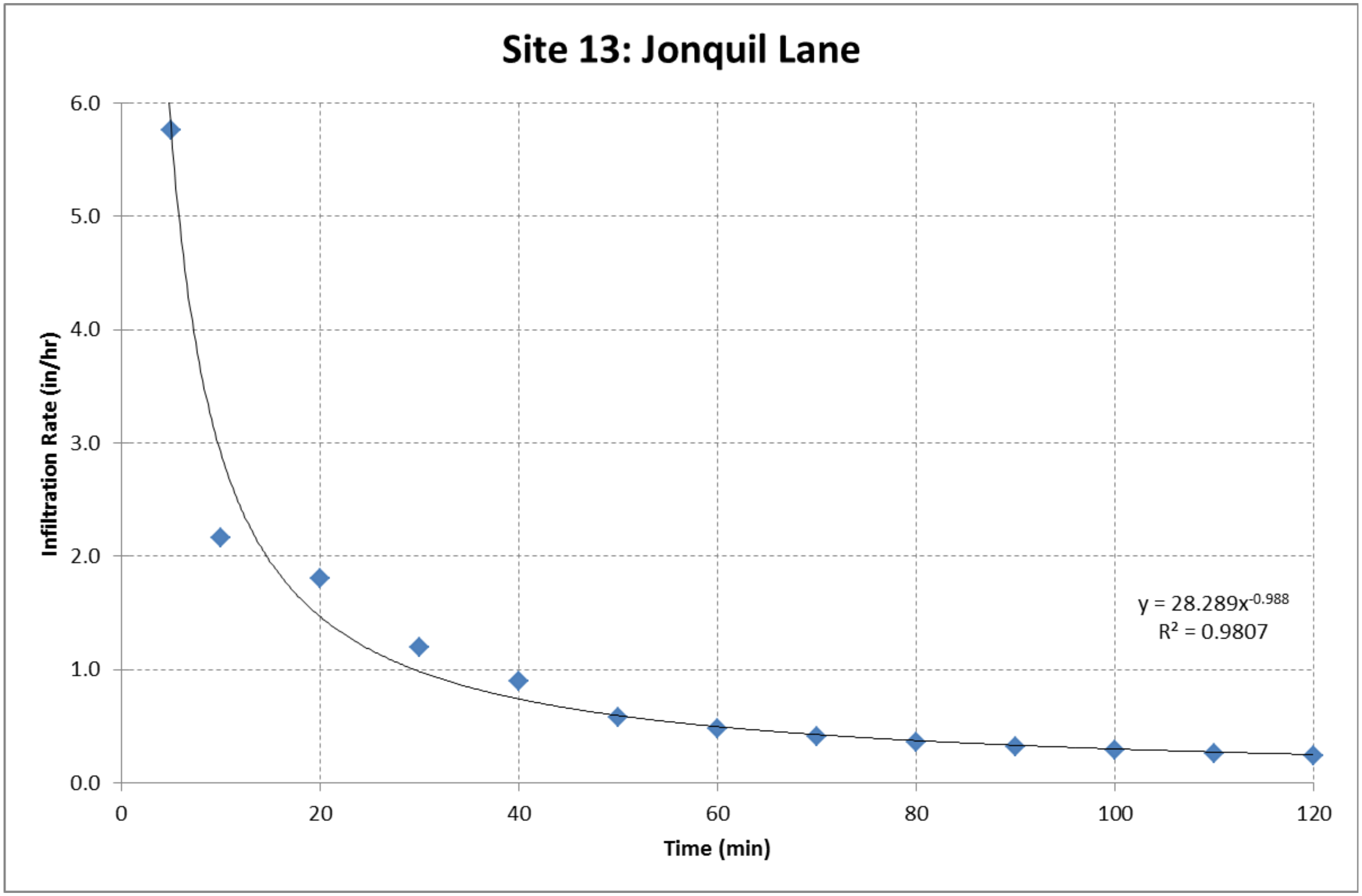

Site 9: Cloverland Lane
Infiltration Rate (in/hr)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 28.248x^-0.883
R² = 0.7606



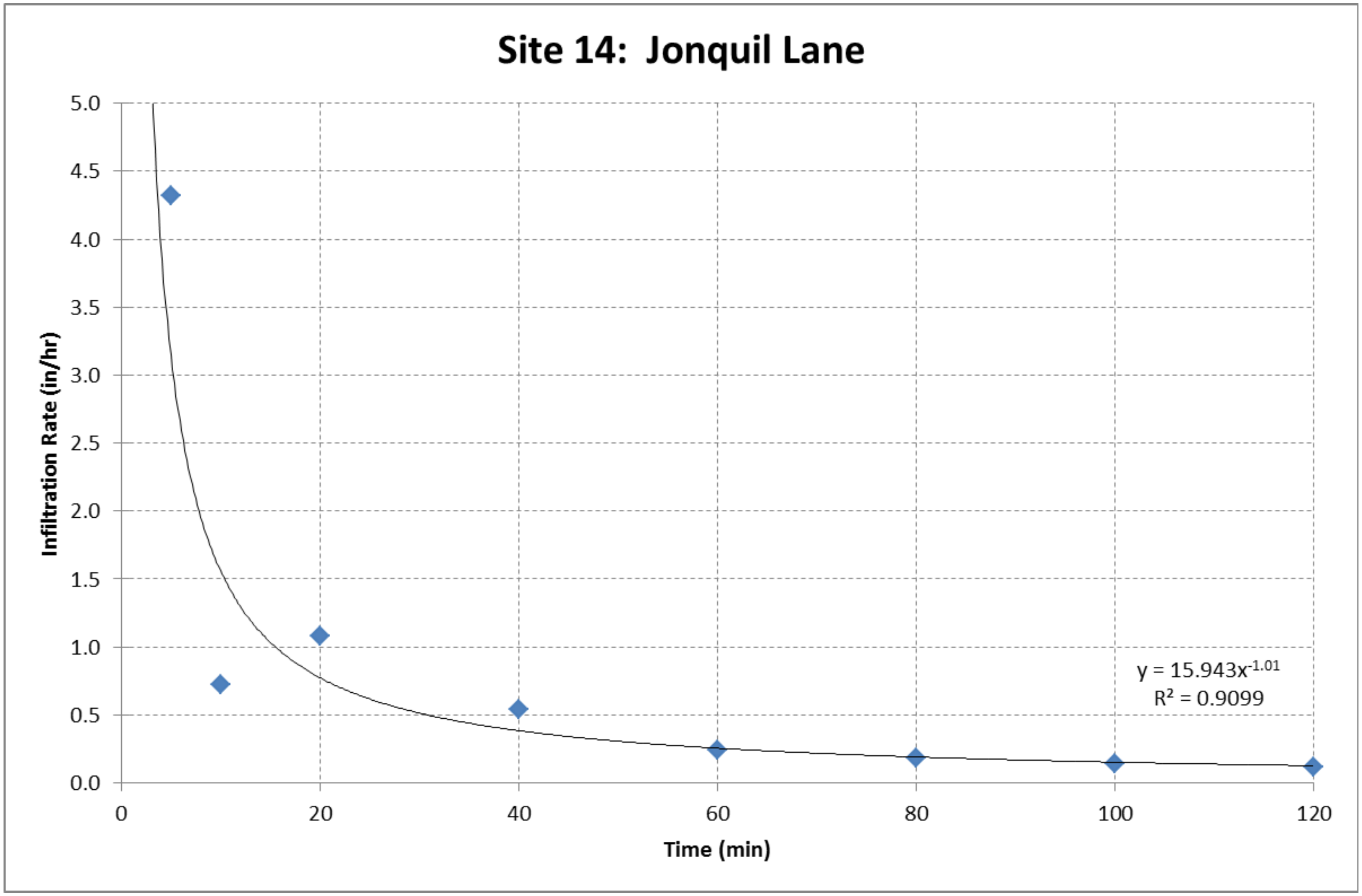
Site 10: Swan Avenue
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Infiltration Rate (in/hr)
0
20
40
60
80
100
120
Time (min)
y = 367.92x^-1.13
R² = 0.9831

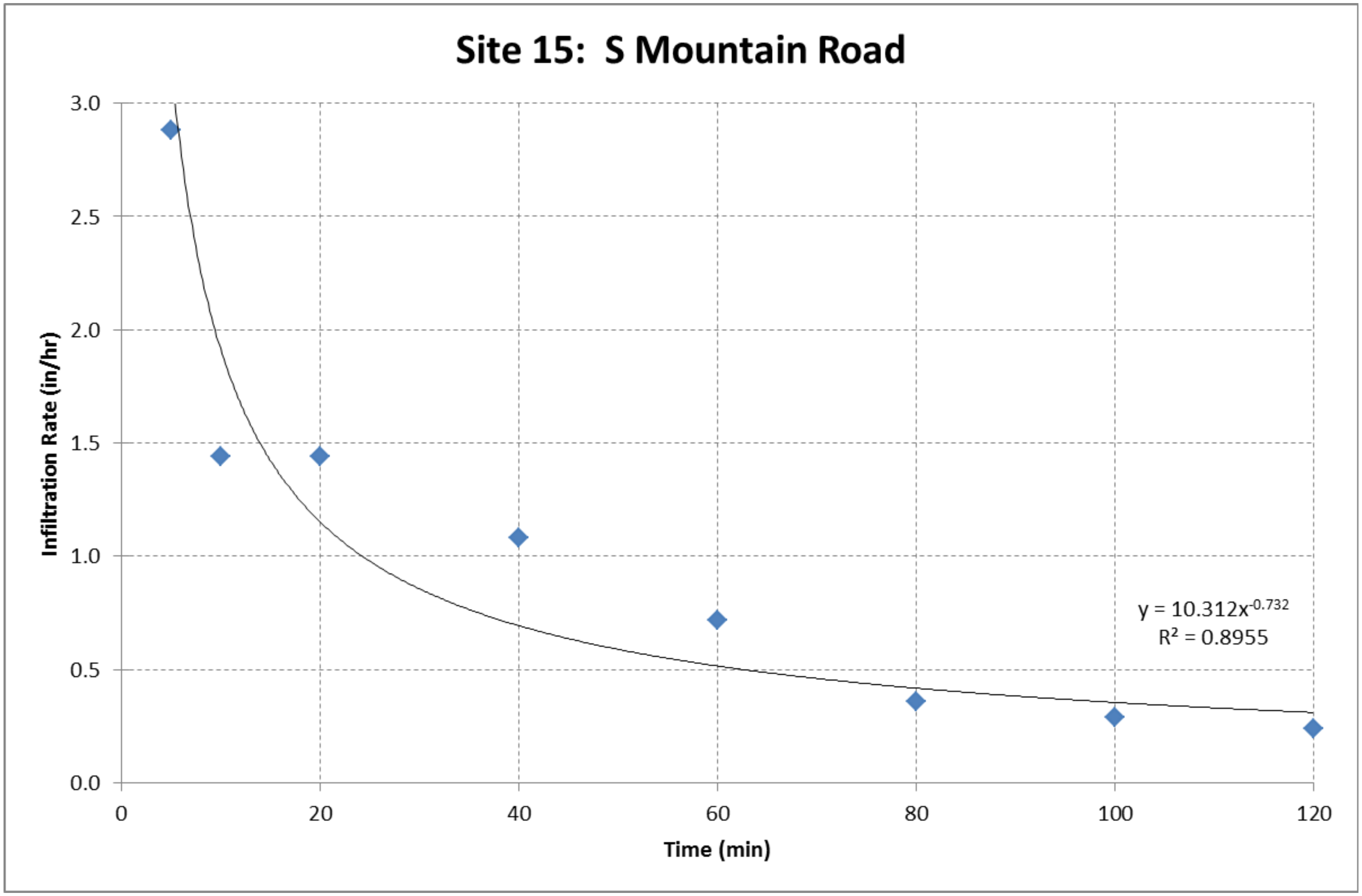

Site 11: Dahlia Lane
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Infiltration Rate (in/hr)
0
20
40
60
80
100
120
Time (min)
y = 450.11x^-1.195
R² = 0.9725

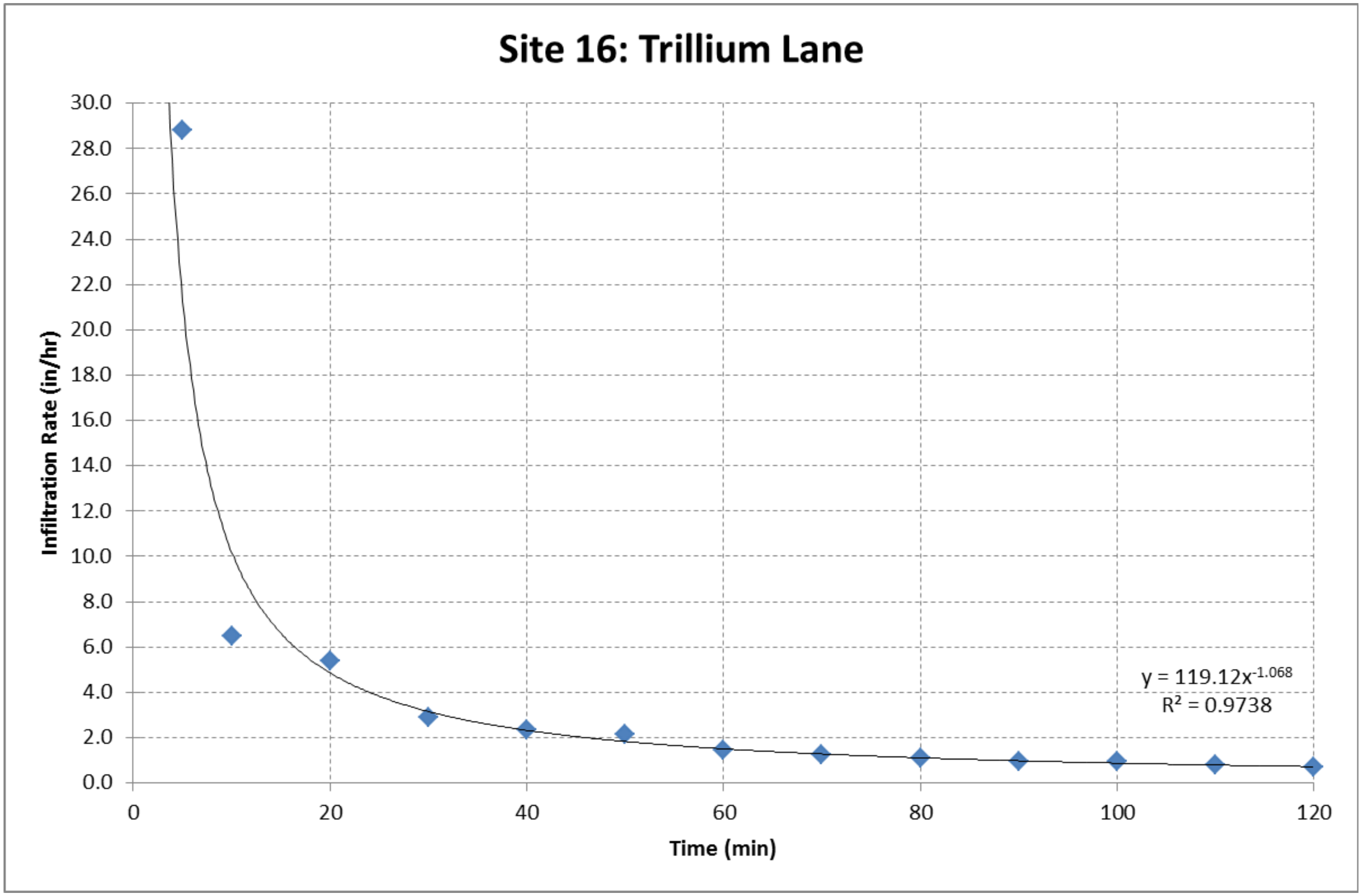

Site 12: Jonquil Lane
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Infiltration Rate (in/hr)
0
20
40
60
80
100
120
Time (min)
$y = 51.669x^{-0.833}$
$R^2 = 0.9839$



Site 13: Jonquil Lane
Infiltration Rate (in/hr)
Time (min)
y = 28.289x^-0.988
R² = 0.9807
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120

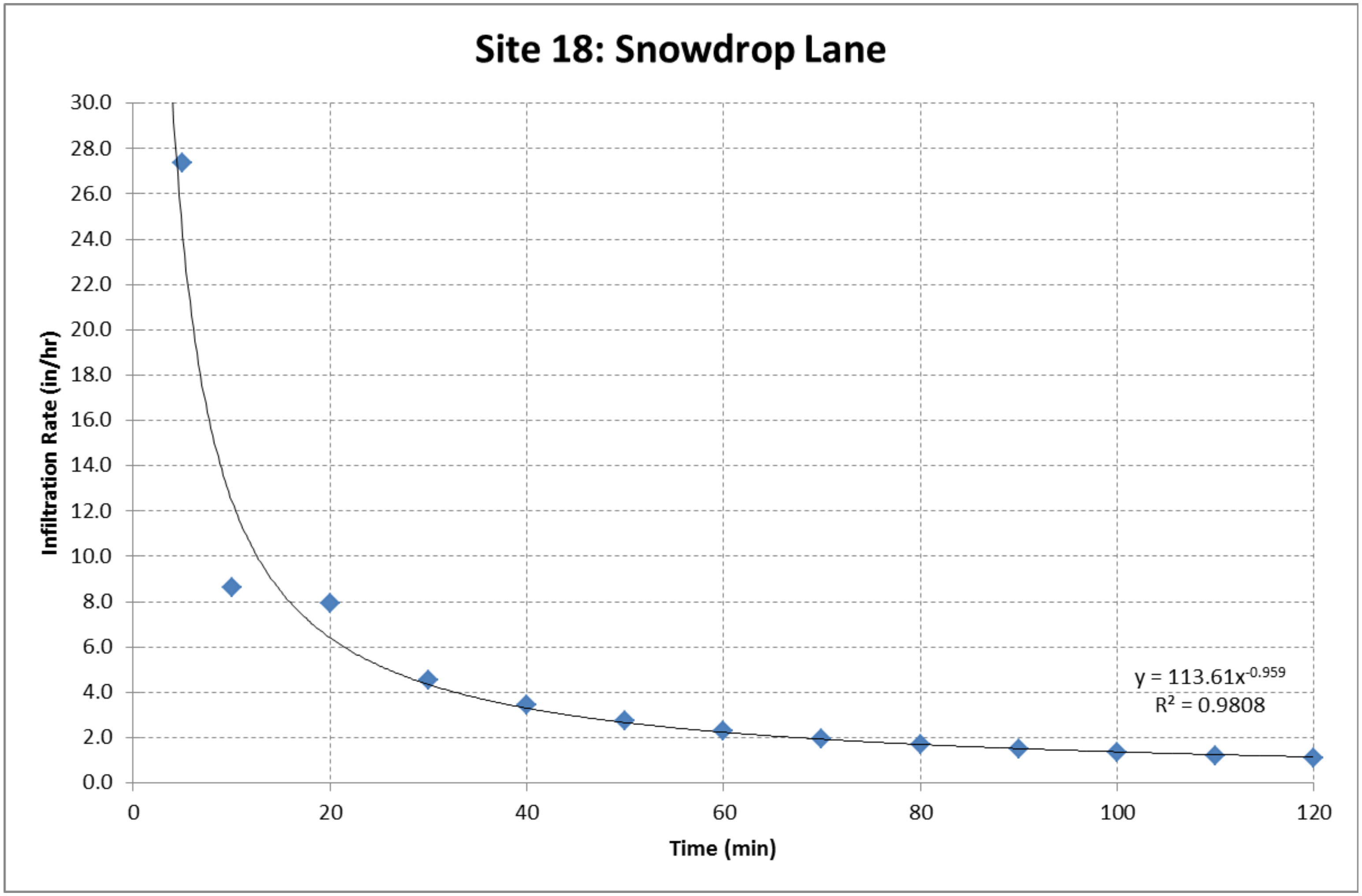

Site 14: Jonquil Lane
Infiltration Rate (in/hr)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
120
Time (min)
$y = 15.943x^{-1.01}$
$R^2 = 0.9099$

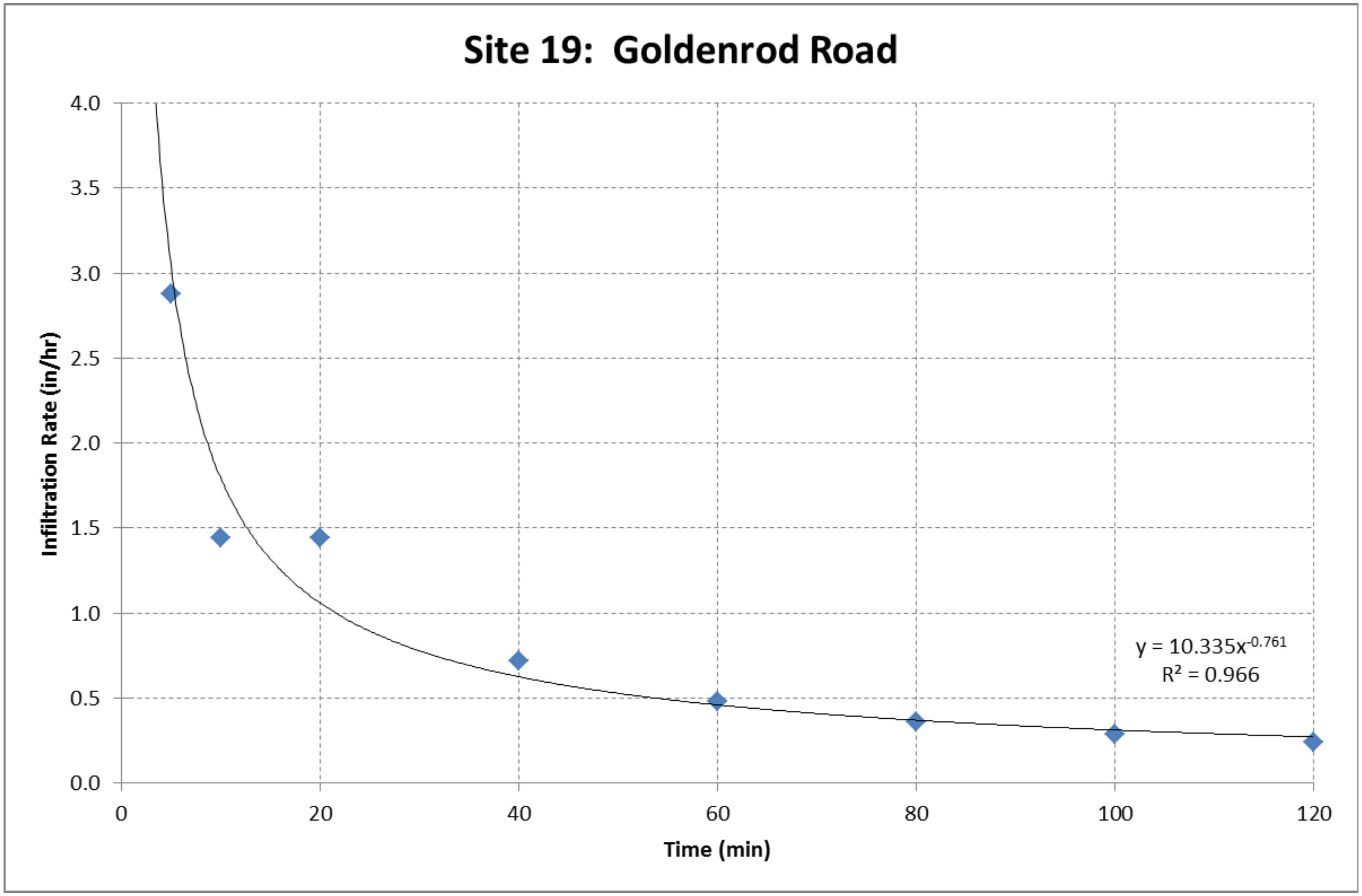

Site 15: S Mountain Road
Infiltration Rate (in/hr)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
120
Time (min)
y = 10.312x^-0.732
R² = 0.8955

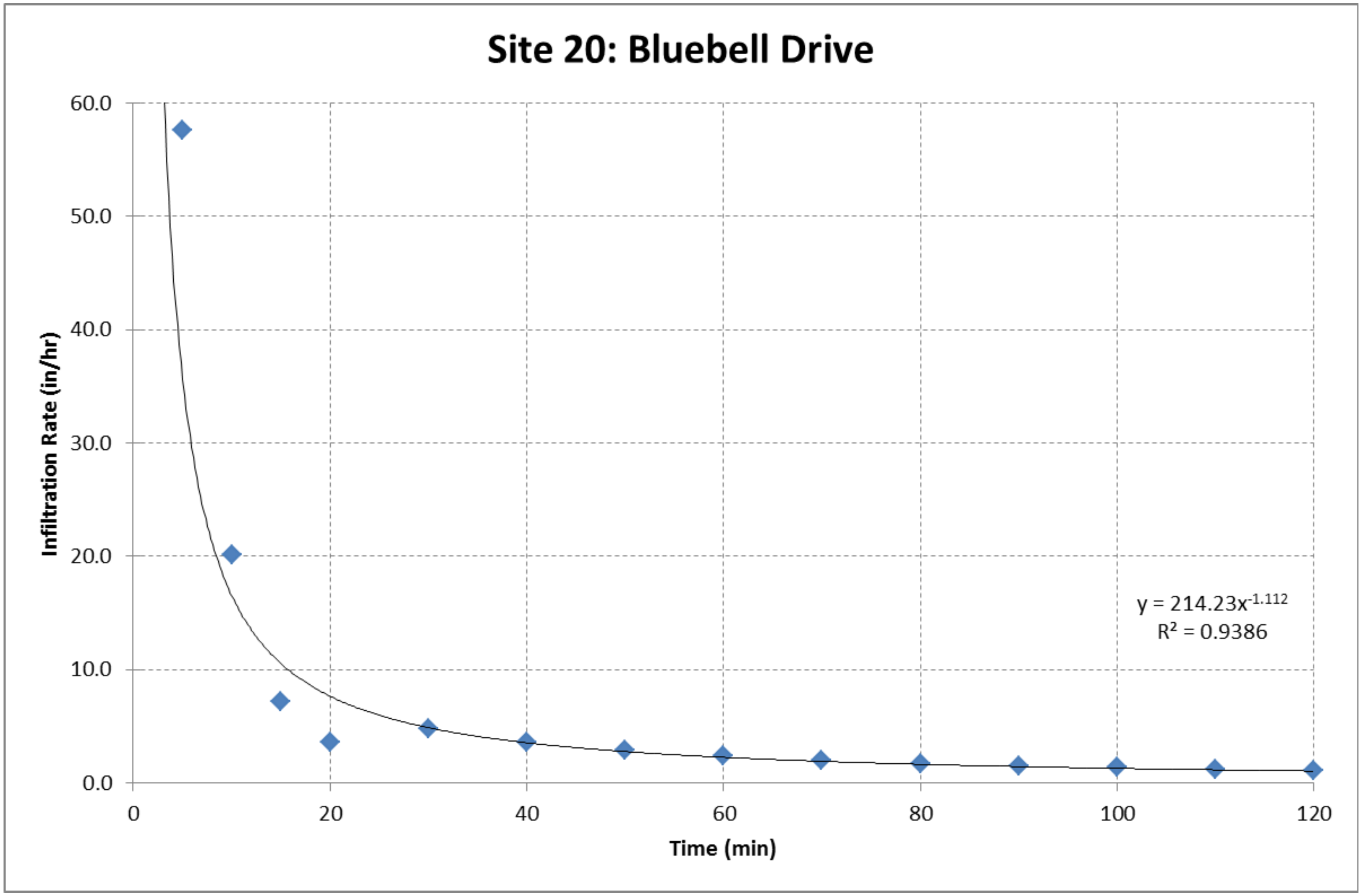


Site 16: Trillium Lane
Infiltration Rate (in/hr)
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 119.12x^-1.068
R² = 0.9738


Site 17: Moonlite Avenue
Infiltration Rate (in/hr)
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120
Time (min)
$y = 45.645x^{-0.846}$
$R^2 = 0.9558$


Site 18: Snowdrop Lane
Infiltration Rate (in/hr)
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 113.61x^-0.959
R² = 0.9808

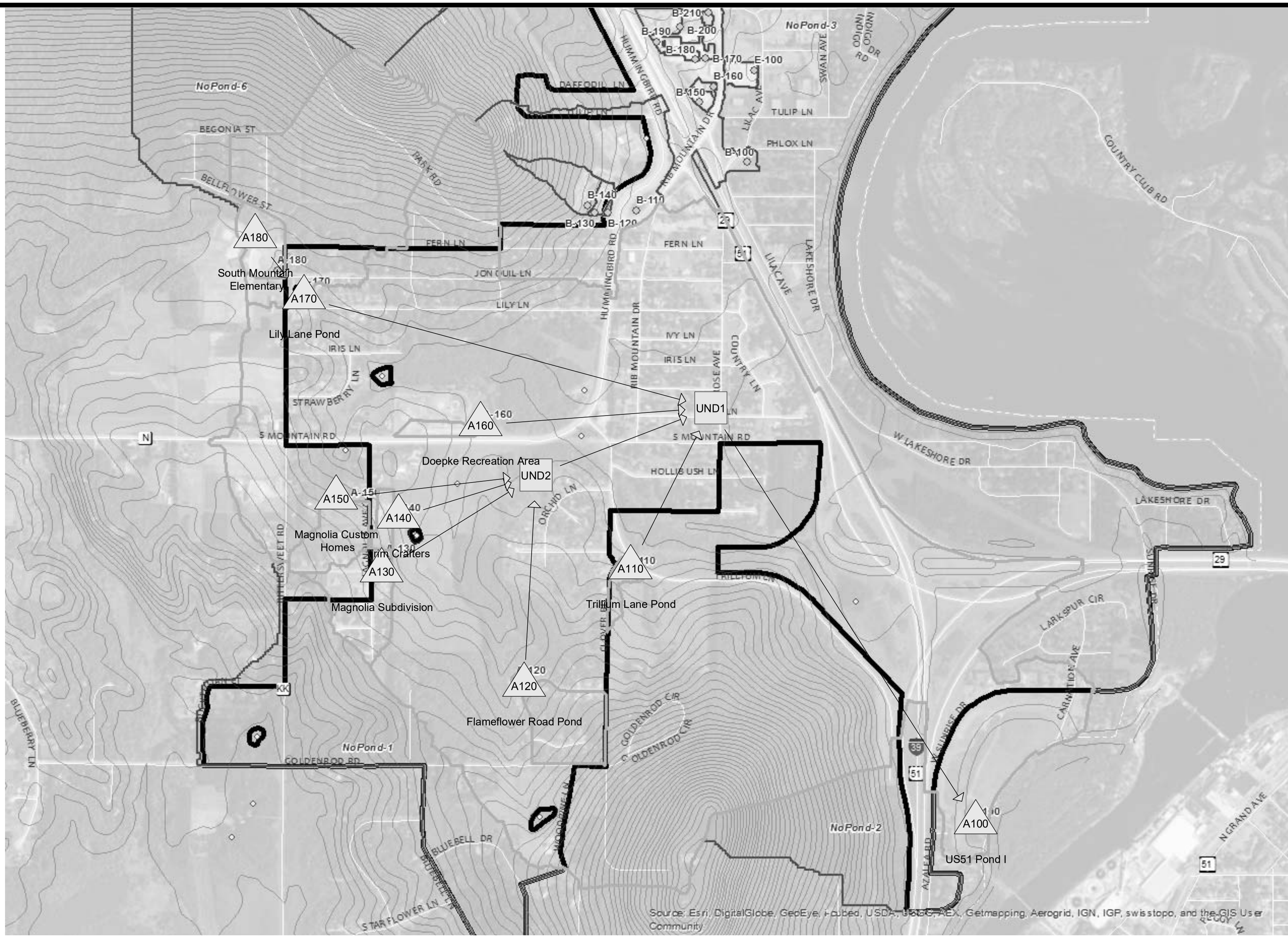

Site 19: Goldenrod Road
Infiltration Rate (in/hr)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
120
Time (min)
y = 10.335x^-0.761
R² = 0.966



Site 20: Bluebell Drive
Infiltration Rate (in/hr)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
120
Time (min)
y = 214.23x^-1.112
R² = 0.9386

APPENDIX C

Outfall BMP (Ponds) Geometric Data



Subcat | Reach | Pond | Link

Routing Diagram for Area A

Prepared by MSA Professional Services, Inc., Printed 9/26/2017

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Summary for Reach UND1:

[40] Hint: Not Described (Outflow=Inflow)

Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Reach UND2:

[40] Hint: Not Described (Outflow=Inflow)

Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond A100: US51 Pond I

Pond data from WDOT Plans dated 05-09-05

Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
Primary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 1,143.00' @ 5.00 hrs Surf.Area= 1.577 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	1,143.00'	180.940 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,143.00	1.577	0.000	0.000
1,144.00	1.685	1.631	1.631
1,145.00	1.797	1.741	3.372
1,146.00	1.954	1.875	5.247
1,147.00	5.773	3.863	9.111
1,148.00	14.657	10.215	19.326
1,149.00	18.911	16.784	36.110
1,150.00	22.657	20.784	56.894
1,152.00	24.576	47.233	104.127
1,153.00	25.349	24.962	129.089
1,154.00	25.927	25.638	154.728
1,155.00	26.498	26.212	180.940

Device	Routing	Invert	Outlet Devices
#1	Device 2	1,147.00'	**45.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#2	Primary	1,145.25'	**24.0" Round Culvert X 2.00** L= 130.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 1,145.25' / 1,145.00' S= 0.0019 '/' Cc= 0.900 n= 0.013, Flow Area= 3.14 sf
#3	Secondary	1,153.00'	**50.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,143.00' (Free Discharge)
2=Culvert (Controls 0.00 cfs)
1=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,143.00' (Free Discharge)
3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond A110: Trillium Lane Pond

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond A120: Flameflower Road Pond

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond A130: Magnolia Subdivision

Storage (all) from 2-ft aerial contours
Outlets from Becher Hoppe Plans revised 10-11-07

Inflow	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Starting Elev= 1,230.02' Surf.Area= 0.210 ac Storage= 0.414 af
Peak Elev= 1,230.02' @ 5.00 hrs Surf.Area= 0.210 ac Storage= 0.414 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	1,226.00'	2.663 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,226.00	0.001	0.000	0.000
1,228.00	0.100	0.101	0.101
1,230.00	0.209	0.309	0.410
1,232.00	0.311	0.520	0.930
1,234.00	0.427	0.738	1.668
1,236.00	0.568	0.995	2.663

Device	Routing	Invert	Outlet Devices
#1	Primary	1,230.02'	**8.0" Round Culvert** L= 60.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,230.02' / 1,230.00' S= 0.0003 '/' Cc= 0.900 n= 0.024, Flow Area= 0.35 sf
#2	Primary	1,234.20'	**12.0" Round Culvert** L= 27.0' CMP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 1,234.20' / 1,234.05' S= 0.0056 '/' Cc= 0.900 n= 0.024, Flow Area= 0.79 sf
#3	Primary	1,235.00'	**16.0' long x 19.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,230.02' (Free Discharge)
1=Culvert (Controls 0.00 cfs)
2=Culvert (Controls 0.00 cfs)
3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond A140: Trim Crafters

Pond Data from MTS report dated 02-21-13

[43] Hint: Has no inflow (Outflow=Zero)

Volume	Invert	Avail.Storage	Storage Description
#1	1,224.00'	0.271 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,224.00	0.000	0.000	0.000
1,225.00	0.063	0.032	0.032
1,226.00	0.416	0.239	0.271

Device	Routing	Invert	Outlet Devices
#1	Primary	1,224.00'	**3.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,224.00' / 1,223.90' S= 0.0050 '/' Cc= 0.900 n= 0.010, Flow Area= 0.05 sf

#2	Primary	1,225.00'	**4.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
—**1=Culvert** (Controls 0.00 cfs)
—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond A150: Magnolia Custom Homes

Pond data from REI report revised 07-15-15
HydroCAD report identifies three nealy identical infiltration ponds which have been combined as one basin here. Infiltration rate from previous version of report WinSLAMM data.

[43] Hint: Has no inflow (Outflow=Zero)

Volume	Invert	Avail.Storage	Storage Description
#1	0.00'	14,723 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
0.00	4,386	0	0
1.00	7,209	5,798	5,798
2.00	10,642	8,926	14,723

Device	Routing	Invert	Outlet Devices
#1	Primary	1.50'	**18.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#2	Discarded	0.00'	**0.130 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
—**2=Exfiltration** (Passes 0.00 cfs of 0.01 cfs potential flow)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond A160: Doepke Recreation Area

No Plans Provided

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond A170: Lily Lane Pond

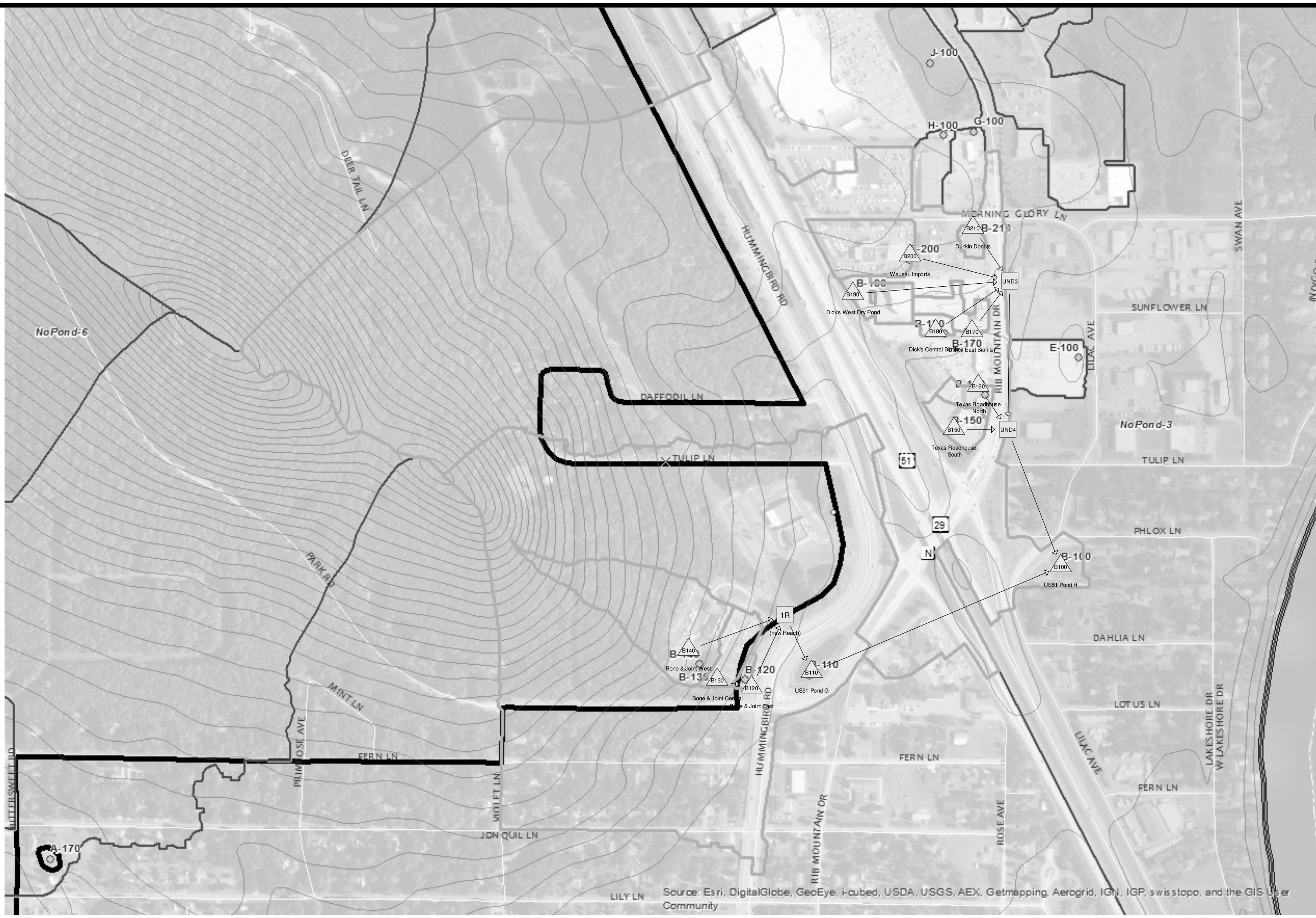
[40] Hint: Not Described (Outflow=Inflow)

Routing by Stor-Ind method

Summary for Pond A180: South Mountain Elementary

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)



Routing Diagram for Area B

Prepared by MSA Professional Services, Inc., Printed 9/25/2017

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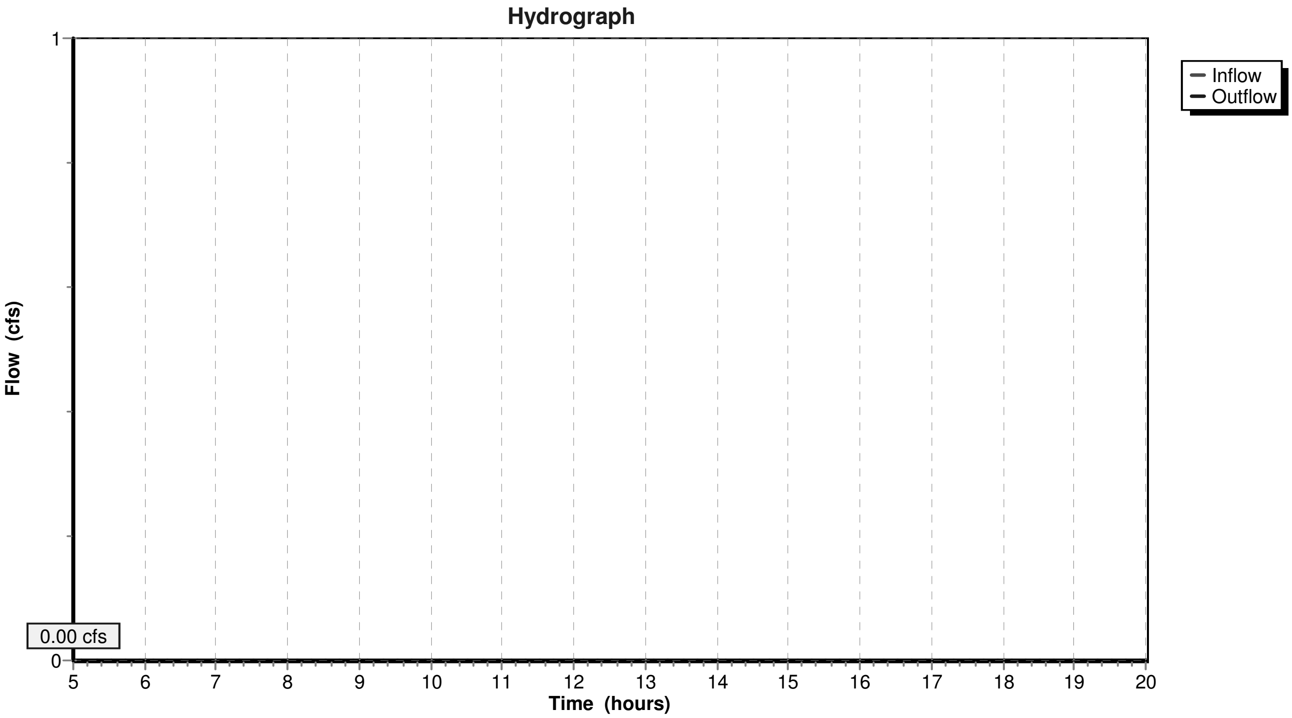
Summary for Reach 1R: (new Reach)

[40] Hint: Not Described (Outflow=Inflow)

Inflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af	
Outflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Reach 1R: (new Reach)



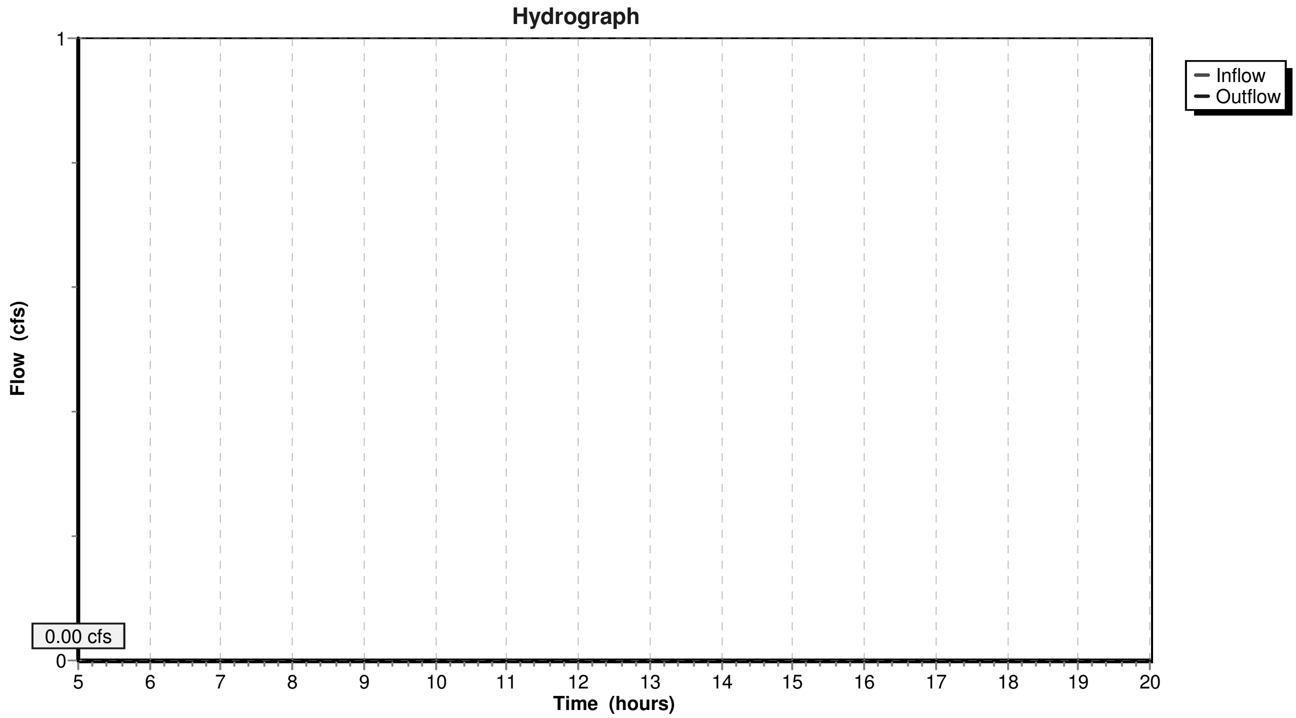
Summary for Reach UND3:

[40] Hint: Not Described (Outflow=Inflow)

Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Reach UND3:



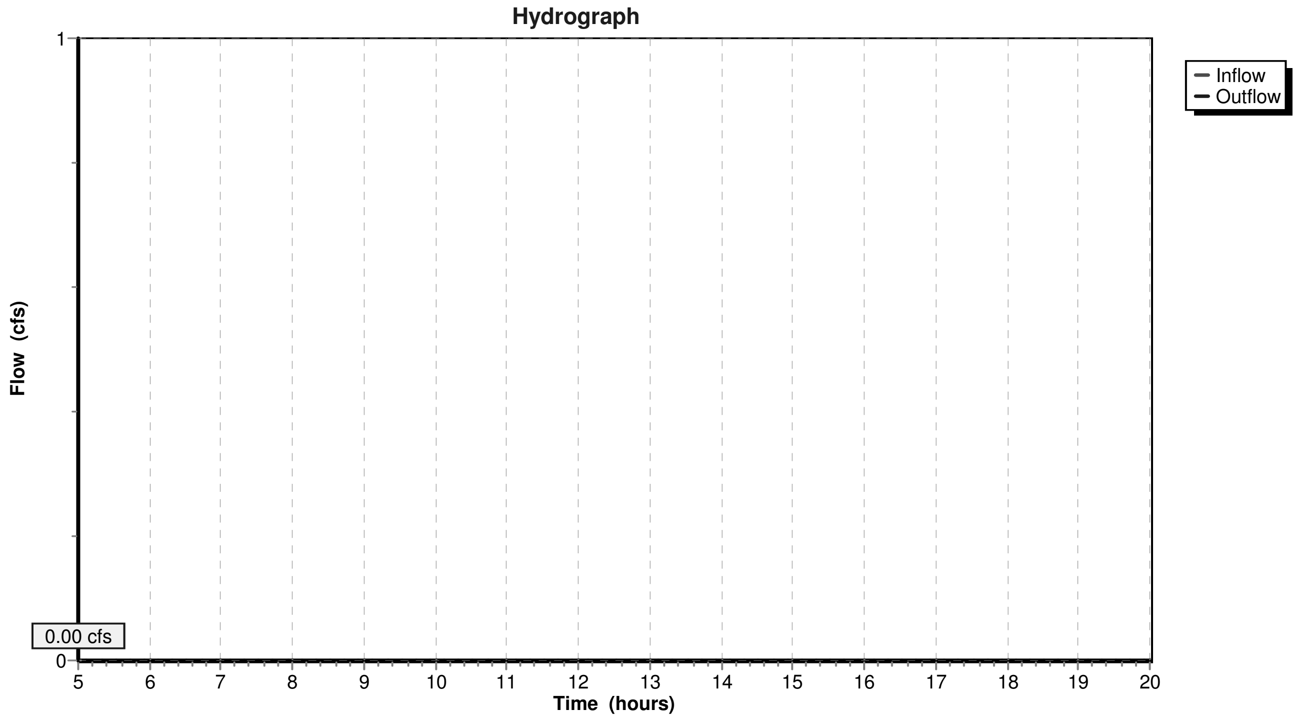
Summary for Reach UND4:

[40] Hint: Not Described (Outflow=Inflow)

Inflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Reach UND4:



Summary for Pond B100: US51 Pond H

Pond data from WDOT plans dated 12-28-03

Inflow	=	0.00 cfs @ 5.00 hrs,	Volume=	0.000 af
Outflow	=	0.00 cfs @ 5.00 hrs,	Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @ 5.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 1,184.00' @ 5.00 hrs Surf.Area= 0.139 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

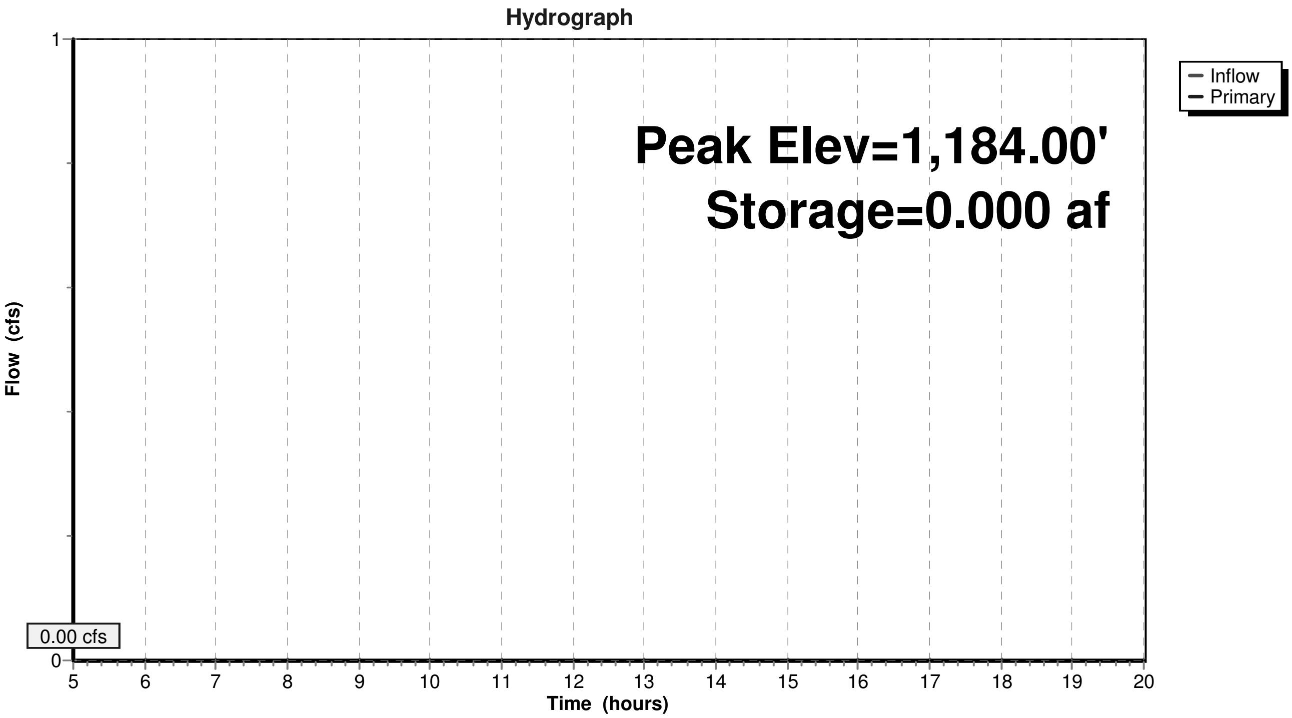
Volume	Invert	Avail.Storage	Storage Description
#1	1,184.00'	3.892 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,184.00	0.139	0.000	0.000
1,185.00	0.180	0.159	0.159
1,186.00	0.263	0.222	0.381
1,187.00	0.333	0.298	0.679
1,188.00	0.412	0.372	1.052
1,189.50	0.688	0.825	1.876
1,190.00	0.731	0.355	2.231
1,191.00	0.820	0.775	3.007
1,192.00	0.951	0.885	3.892

Device	Routing	Invert	Outlet Devices
#1	Primary	1,189.50'	**23.0" W x 14.0" H, R=22.0" Elliptical RCP_Elliptical 23x14** L= 50.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 1,189.50' / 1,189.35' S= 0.0030 '/' Cc= 0.900 n= 0.013, Flow Area= 1.83 sf
#2	Primary	1,191.50'	**45.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,184.00' (Free Discharge)
└─**1=RCP_Elliptical 23x14** (Controls 0.00 cfs)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond B100: US51 Pond H



Summary for Pond B110: US51 Pond G

Pond data from WDOT plans dated 12-28-03
Culvert diameter not shown on plans - assumed dual 24" dia.

Inflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 1,188.00' @ 5.00 hrs Surf.Area= 0.663 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

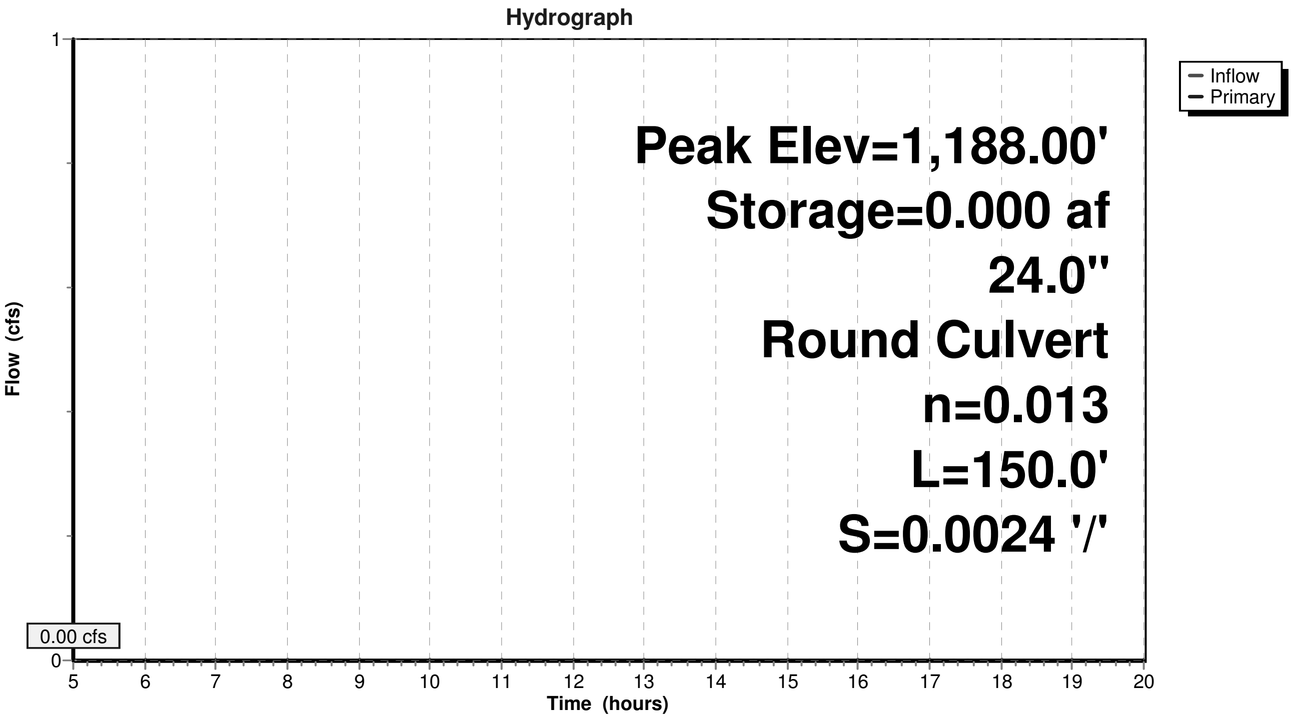
Volume	Invert	Avail.Storage	Storage Description
#1	1,188.00'	13.503 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,188.00	0.663	0.000	0.000
1,190.00	0.779	1.442	1.442
1,192.00	0.889	1.668	3.110
1,193.00	1.384	1.137	4.246
1,194.00	1.567	1.475	5.722
1,196.00	1.941	3.508	9.230
1,198.00	2.332	4.273	13.503

Device	Routing	Invert	Outlet Devices
#1	Primary	1,193.00'	**24.0" Round Culvert** L= 150.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 1,193.00' / 1,192.64' S= 0.0024 '/' Cc= 0.900 n= 0.013, Flow Area= 3.14 sf

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,188.00' (Free Discharge)
└─**1=Culvert** (Controls 0.00 cfs)

Pond B110: US51 Pond G



Summary for Pond B120: Bone & Joint East

Pond data above NWL from REI report dated 06-25-07, data below NWL measured from plans data 06-22-07

Inflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 1,205.00' @ 5.00 hrs Surf.Area= 0.000 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

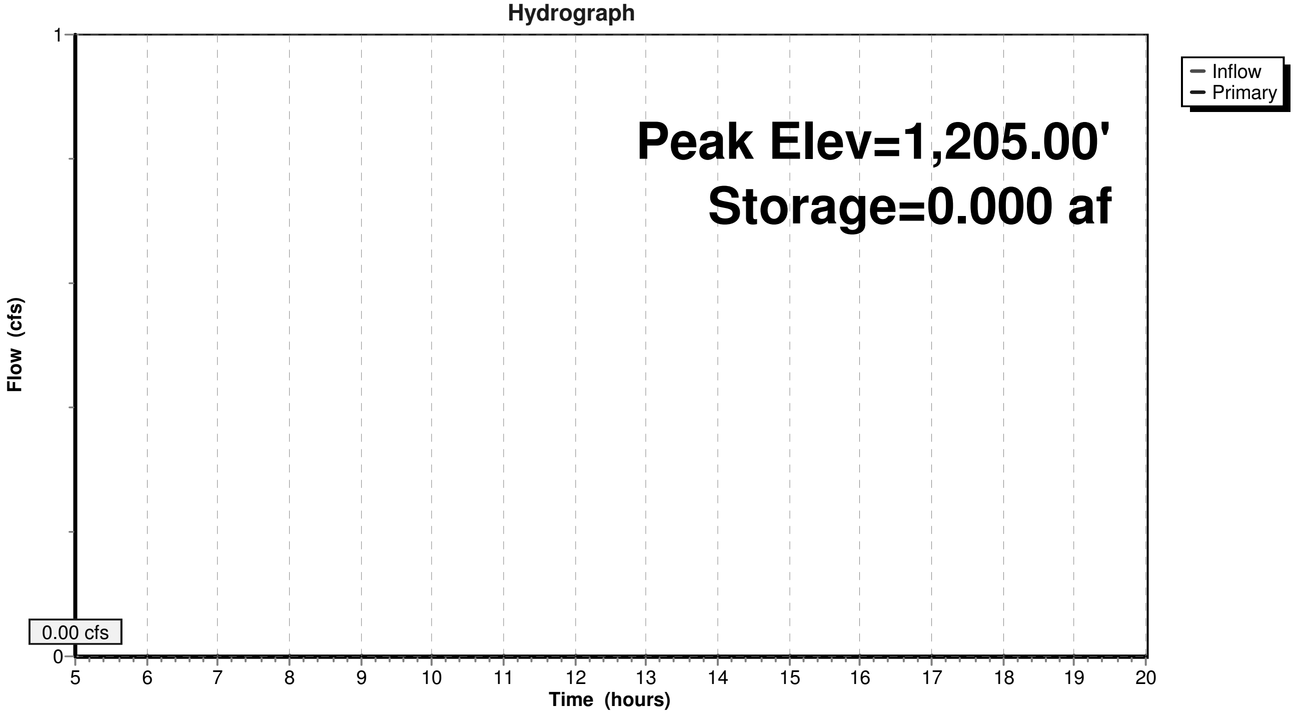
Volume	Invert	Avail.Storage	Storage Description
#1	1,205.00'	0.178 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,205.00	0.000	0.000	0.000
1,206.00	0.006	0.003	0.003
1,207.00	0.017	0.011	0.014
1,207.50	0.028	0.011	0.026
1,208.00	0.039	0.017	0.043
1,209.00	0.066	0.052	0.095
1,210.00	0.100	0.083	0.178

Device	Routing	Invert	Outlet Devices
#1	Primary	1,207.50'	**8.0" Round Culvert** L= 32.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,207.50' / 1,207.00' S= 0.0156 '/' Cc= 0.900 n= 0.011, Flow Area= 0.35 sf
#2	Primary	1,209.50'	**5.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,205.00' (Free Discharge)
└─**1=Culvert** (Controls 0.00 cfs)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond B120: Bone & Joint East



Summary for Pond B130: Bone & Joint Central

Pond data above NWL from REI report dated 06-25-07, data below NWL measured from plans data 06-22-07

Inflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Starting Elev= 1,218.00' Surf.Area= 0.056 ac Storage= 0.070 af
Peak Elev= 1,218.00' @ 5.00 hrs Surf.Area= 0.056 ac Storage= 0.070 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

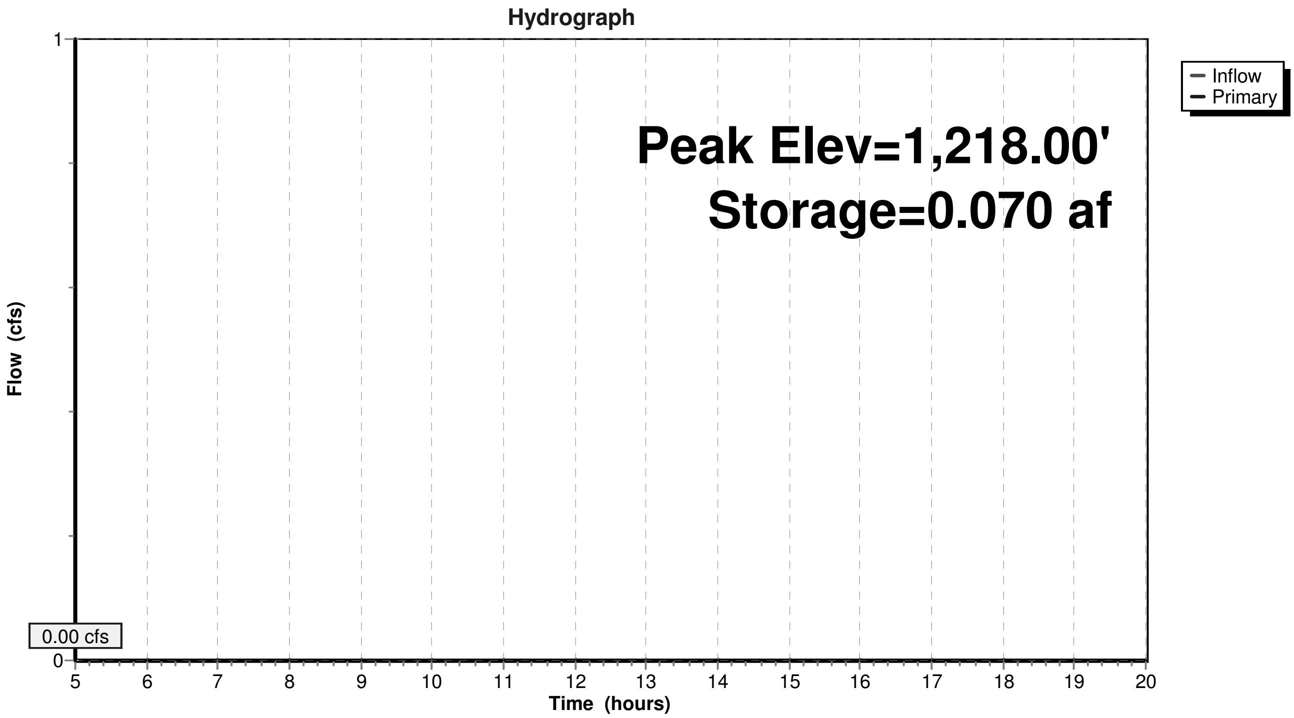
Volume	Invert	Avail.Storage	Storage Description
#1	1,213.00'	0.237 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,213.00	0.001	0.000	0.000
1,214.00	0.004	0.003	0.003
1,215.00	0.007	0.006	0.008
1,216.00	0.012	0.010	0.018
1,217.00	0.019	0.016	0.033
1,218.00	0.056	0.037	0.070
1,219.00	0.082	0.069	0.140
1,220.00	0.114	0.098	0.237

Device	Routing	Invert	Outlet Devices
#1	Primary	1,217.00'	**12.0" Round Culvert** L= 101.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,217.00' / 1,215.00' S= 0.0198 '/' Cc= 0.900 n= 0.011, Flow Area= 0.79 sf
#2	Device 1	1,218.00'	**12.0" Round Culvert** L= 10.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,218.00' / 1,217.00' S= 0.1000 '/' Cc= 0.900 n= 0.011, Flow Area= 0.79 sf
#3	Primary	1,219.50'	**10.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,218.00' (Free Discharge)
└─**1=Culvert** (Passes 0.00 cfs of 2.11 cfs potential flow)
  └─**2=Culvert** (Controls 0.00 cfs)
└─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond B130: Bone & Joint Central



Summary for Pond B140: Bone & Joint West

Pond data above NWL from REI report dated 06-25-07, data below NWL measured from plans data 06-22-07

Inflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Starting Elev= 1,221.00' Surf.Area= 0.188 ac Storage= 0.426 af
Peak Elev= 1,221.00' @ 5.00 hrs Surf.Area= 0.188 ac Storage= 0.426 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

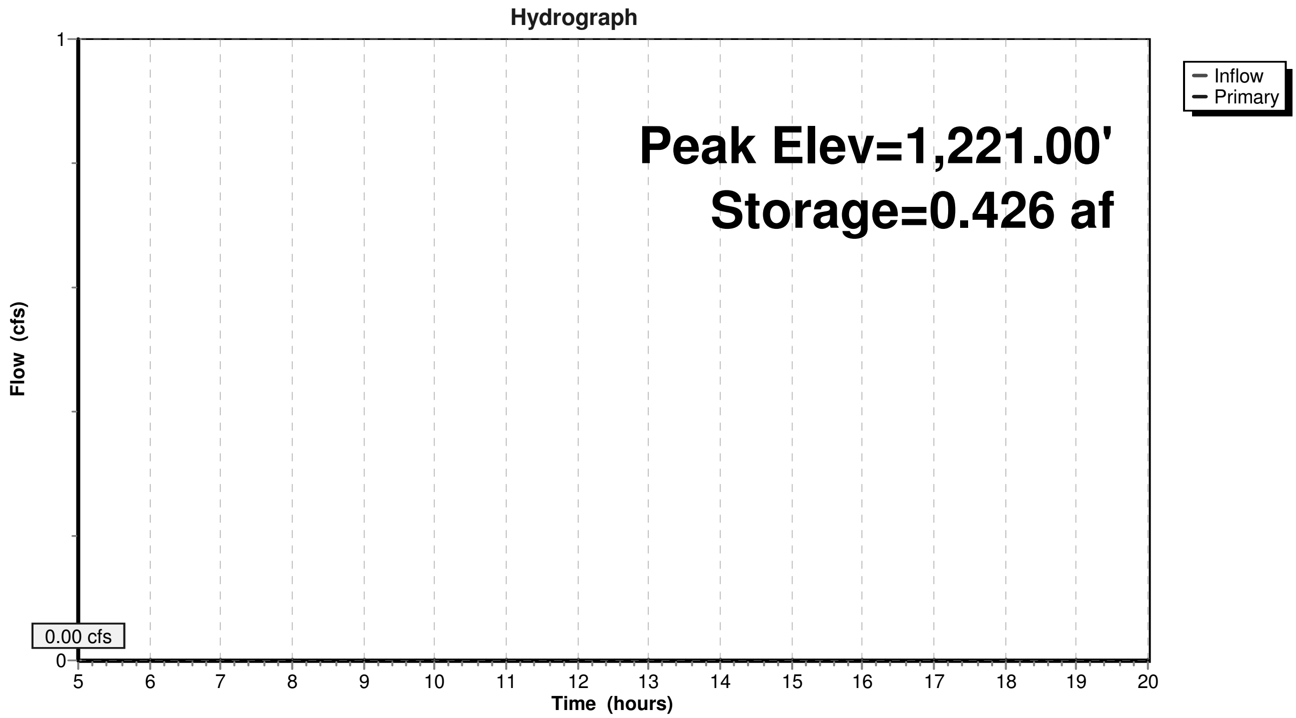
Volume	Invert	Avail.Storage	Storage Description
#1	1,216.00'	1.538 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,216.00	0.030	0.000	0.000
1,217.00	0.047	0.038	0.038
1,218.00	0.066	0.056	0.095
1,219.00	0.089	0.077	0.173
1,220.00	0.115	0.102	0.275
1,221.00	0.188	0.151	0.426
1,222.00	0.231	0.209	0.635
1,223.00	0.276	0.253	0.889
1,224.00	0.324	0.300	1.189
1,225.00	0.375	0.350	1.538

Device	Routing	Invert	Outlet Devices
#1	Primary	1,221.00'	**6.0" Round Culvert** L= 72.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,221.00' / 1,220.00' S= 0.0139 '/' Cc= 0.900 n= 0.011, Flow Area= 0.20 sf
#2	Primary	1,224.50'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,221.00' (Free Discharge)
↑—**1=Culvert** (Controls 0.00 cfs)
└—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond B140: Bone & Joint West



Summary for Pond B150: Texas Roadhouse South

Pond data from modeling in report by Larson Engineering dated 06-2006

[43] Hint: Has no inflow (Outflow=Zero)

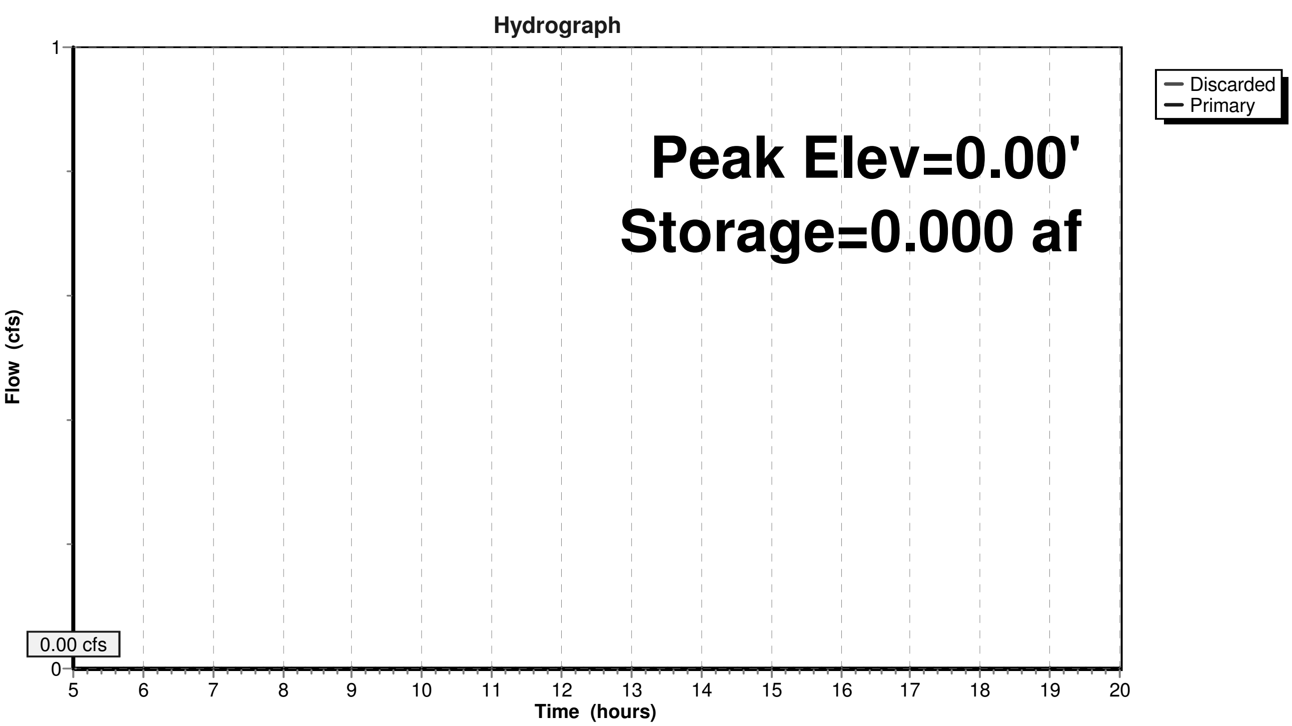
Volume	Invert	Avail.Storage	Storage Description
#1	1,173.75'	0.212 af	**40.00'W x 80.00'L x 2.88'H Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	1,173.75'	**1.0" Vert. Orifice/Grate** C= 0.600
#2	Primary	1,174.70'	**3.5" Vert. Orifice/Grate** C= 0.600
#3	Discarded	1,173.75'	**3.600 in/hr Exfiltration over Horizontal area**

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**3=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
├─**1=Orifice/Grate** (Controls 0.00 cfs)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Pond B150: Texas Roadhouse South



Summary for Pond B160: Texas Roadhouse North

Pond data from modeling in report by Larson Engineering dated 06-2006

[43] Hint: Has no inflow (Outflow=Zero)

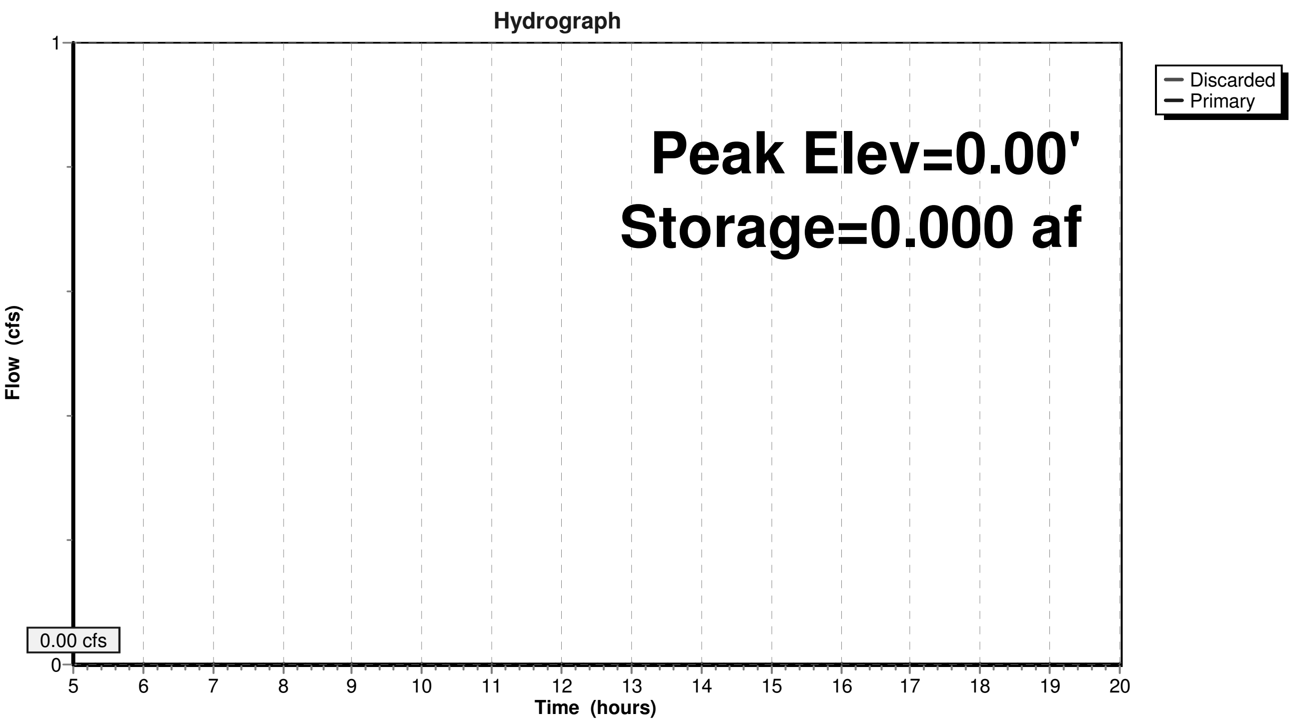
Volume	Invert	Avail.Storage	Storage Description
#1	1,193.75'	0.119 af	**30.00'W x 60.00'L x 2.88'H Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	1,193.75'	**1.5" Vert. Orifice/Grate** C= 0.600
#2	Primary	1,195.00'	**6.0" Vert. Orifice/Grate** C= 0.600
#3	Discarded	1,193.75'	**3.600 in/hr Exfiltration over Horizontal area**

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**3=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
├─**1=Orifice/Grate** (Controls 0.00 cfs)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Pond B160: Texas Roadhouse North



Summary for Pond B170: Dick's East Biofilter

Pond data from model within report by REI dated 07-24-15

[43] Hint: Has no inflow (Outflow=Zero)

Volume	Invert	Avail.Storage	Storage Description
#1	1,203.00'	3,062 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

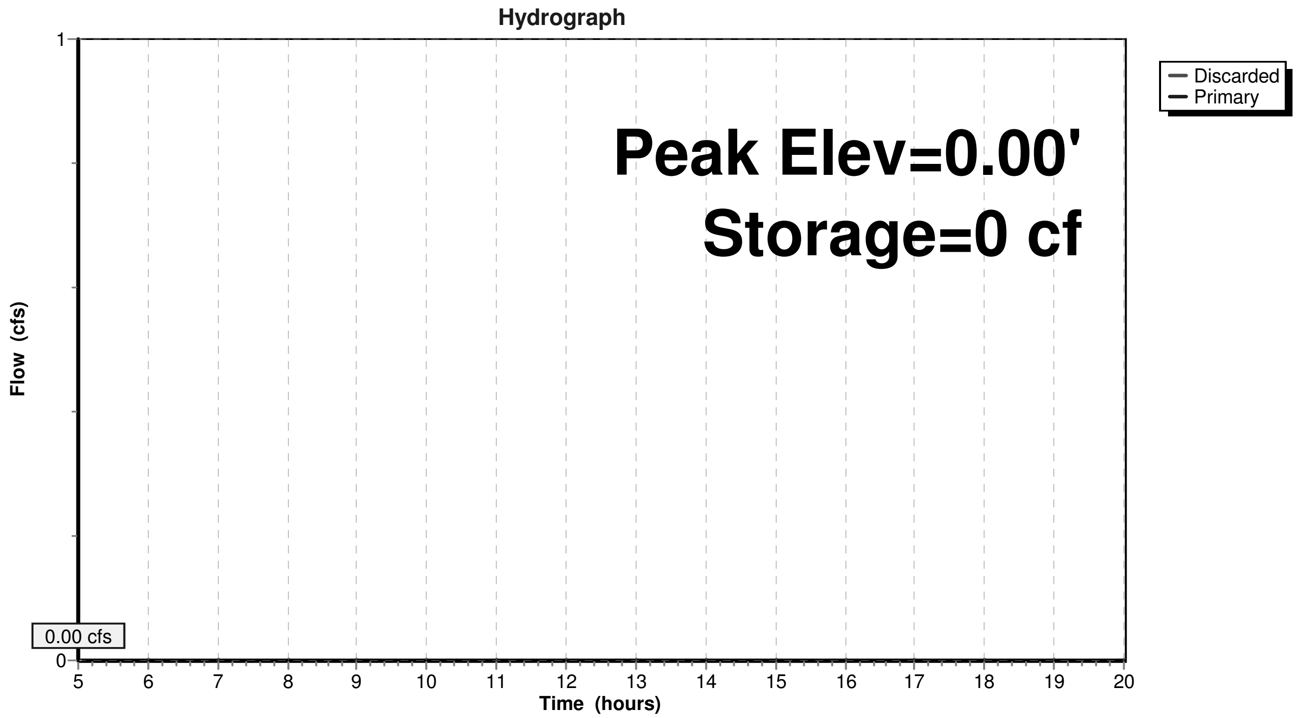
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,203.00	520	0	0
1,204.00	862	691	691
1,205.00	1,229	1,046	1,737
1,206.00	1,422	1,326	3,062

Device	Routing	Invert	Outlet Devices
#1	Primary	1,200.17'	**10.0" Round Culvert** L= 57.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,200.17' / 1,199.92' S= 0.0044 '/' Cc= 0.900 n= 0.011, Flow Area= 0.55 sf
#2	Device 1	1,203.50'	**24.0" Vert. Orifice/Grate X 0.60** C= 0.600
#3	Primary	1,204.70'	**3.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88
#4	Discarded	1,203.00'	**1.630 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**4=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
├─**1=Culvert** (Controls 0.00 cfs)
│ └─**2=Orifice/Grate** (Controls 0.00 cfs)
└─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond B170: Dick's East Biofilter



Summary for Pond B180: Dick's Central Biofilter

Pond data from model within report by REI dated 07-24-15

[43] Hint: Has no inflow (Outflow=Zero)

Volume	Invert	Avail.Storage	Storage Description
#1	1,206.00'	473 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

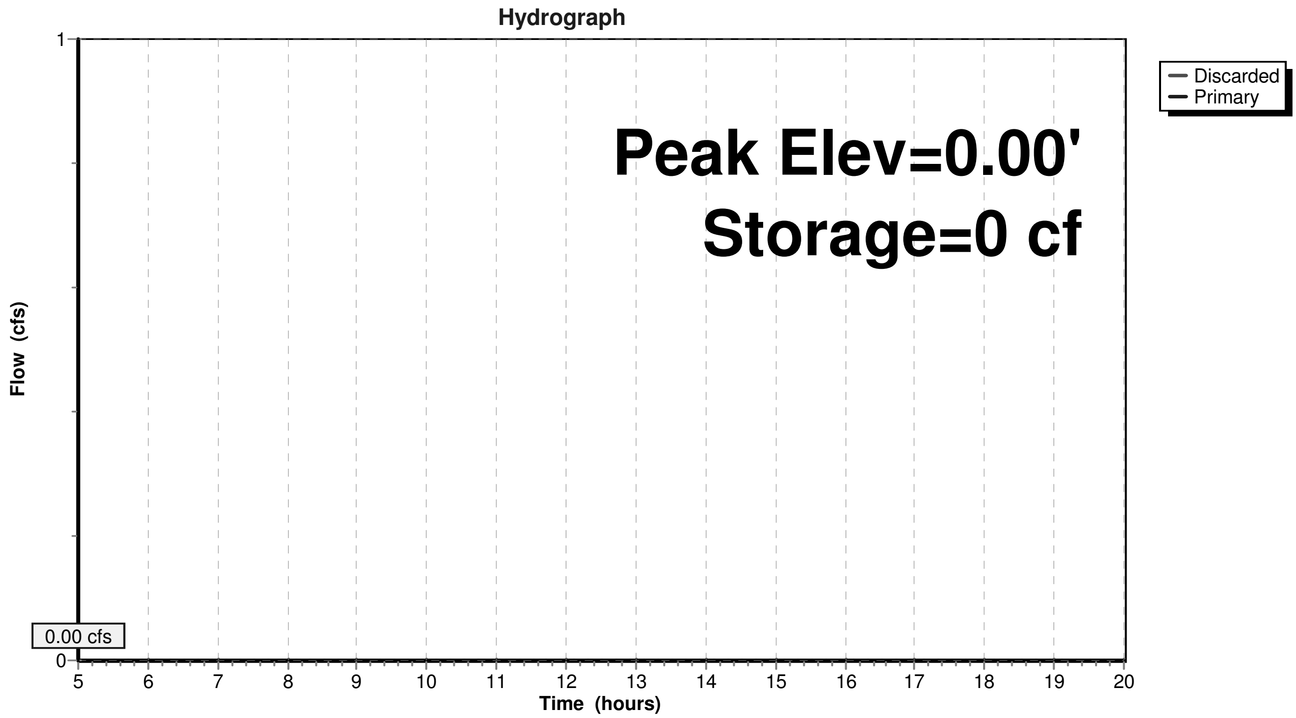
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,206.00	385	0	0
1,206.50	705	273	273
1,206.75	898	200	473

Device	Routing	Invert	Outlet Devices
#1	Discarded	1,206.00'	**1.630 in/hr Exfiltration over Surface area**
#2	Primary	1,206.60'	**3.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88
#3	Device 4	1,206.25'	**24.0" Vert. Orifice/Grate X 0.60** C= 0.600
#4	Primary	1,201.25'	**12.0" Round Culvert** L= 53.0' Ke= 0.900 Inlet / Outlet Invert= 1,201.25' / 1,200.75' S= 0.0094 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**1=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
├─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
└─**4=Culvert** (Controls 0.00 cfs)
  └─**3=Orifice/Grate** (Controls 0.00 cfs)

Pond B180: Dick's Central Biofilter



Summary for Pond B190: Dick's West Dry Pond

Pond data from model within report by REI dated 07-24-15

[43] Hint: Has no inflow (Outflow=Zero)

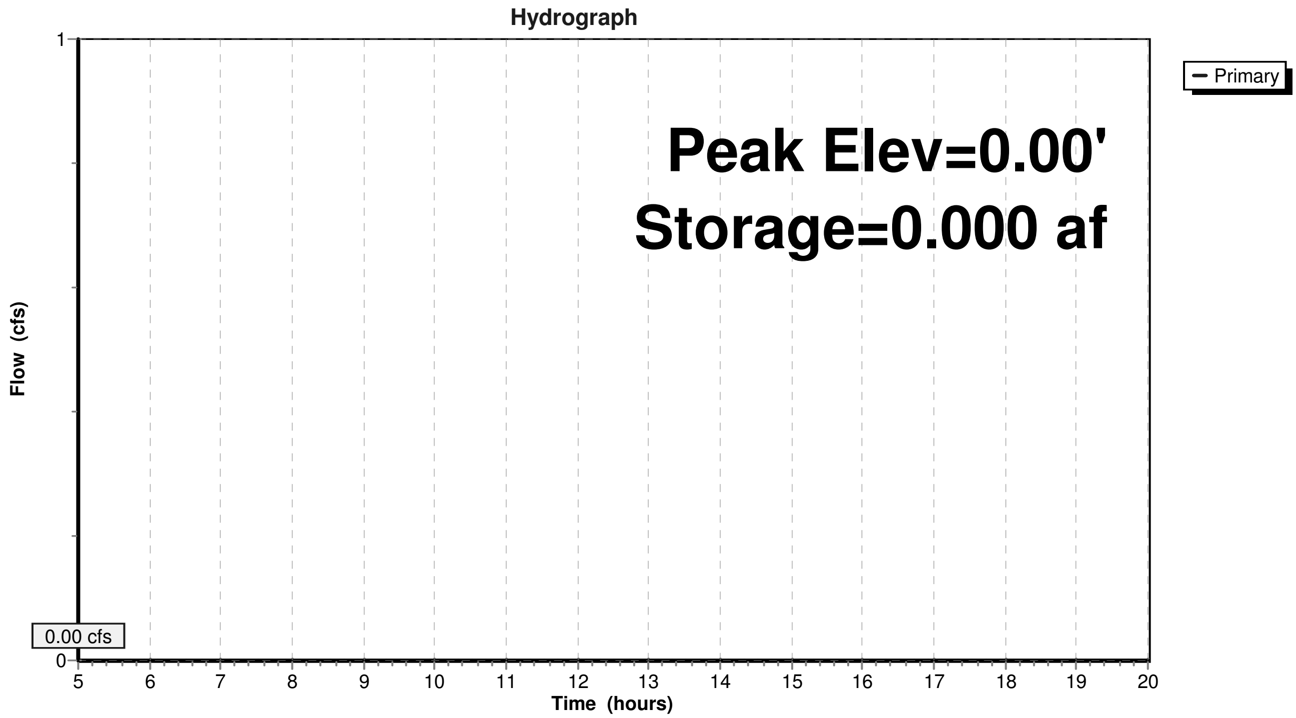
Volume	Invert	Avail.Storage	Storage Description
#1	1,206.00'	0.828 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,206.00	0.000	0.000	0.000
1,207.00	0.023	0.011	0.011
1,208.00	0.069	0.046	0.057
1,209.00	0.087	0.078	0.135
1,210.00	1.299	0.693	0.828

Device	Routing	Invert	Outlet Devices
#1	Primary	1,206.00'	**10.0" Round Culvert** L= 90.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,206.00' / 1,205.55' S= 0.0050 '/' Cc= 0.900 n= 0.011, Flow Area= 0.55 sf
#2	Primary	1,209.50'	**5.0' long x 8.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.43 2.54 2.70 2.69 2.68 2.68 2.66 2.64 2.64 2.64 2.65 2.65 2.66 2.66 2.68 2.70 2.74

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
├─**1=Culvert** (Controls 0.00 cfs)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond B190: Dick's West Dry Pond



Summary for Pond B200: Wausau Imports

Limited Plans, No Calculations

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond B210: Dunkin Donuts

Pond data from modeling in report by Point of Beginning revised 01-29-14 (stamped 02-18-14)

[43] Hint: Has no inflow (Outflow=Zero)

Volume	Invert	Avail.Storage	Storage Description
#1	1,217.00'	2,980 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,217.00	967	0	0
1,218.00	2,184	1,576	1,576
1,218.50	3,434	1,405	2,980

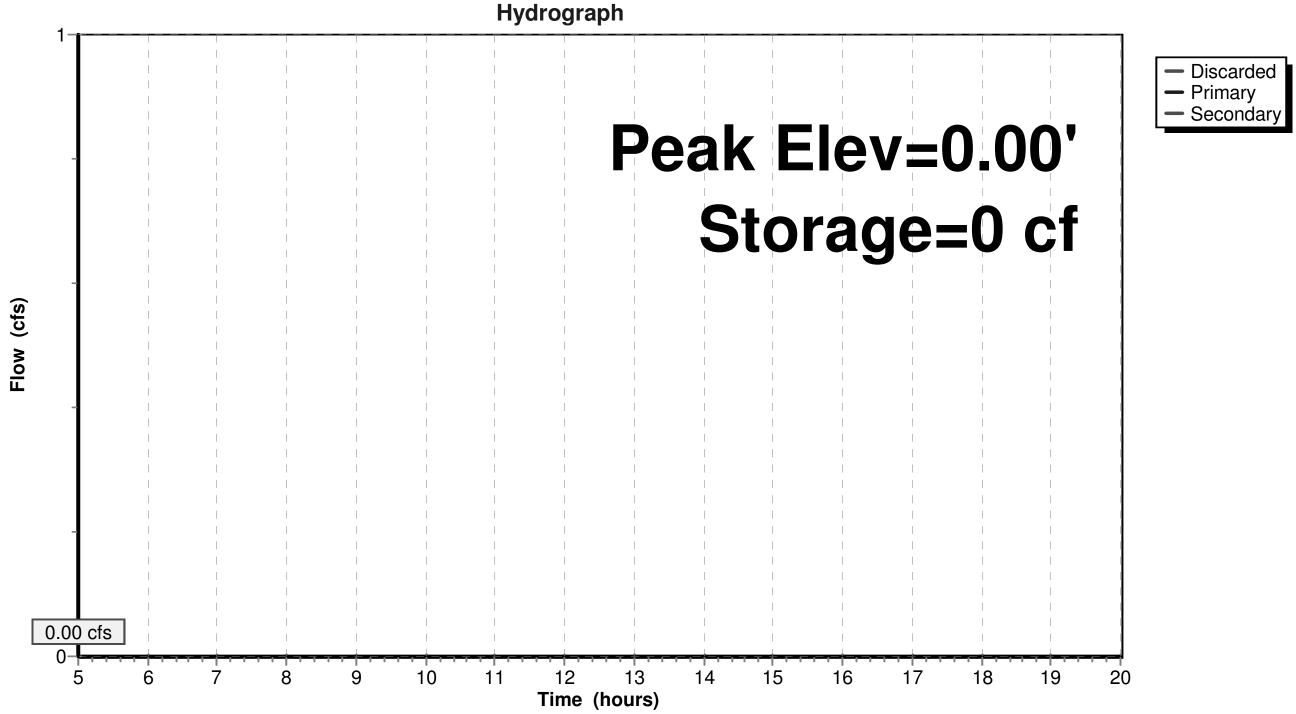
Device	Routing	Invert	Outlet Devices
#1	Primary	1,217.99'	**Beehive Casting** Head (feet) 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Disch. (cfs) 0.000 0.700 2.000 2.700 3.700 4.100 4.500 4.800 5.200 5.500 5.800
#2	Secondary	1,218.00'	**10.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32
#3	Primary	1,217.00'	**4.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Primary	1,217.50'	**3.0" Vert. Orifice/Grate** C= 0.600
#5	Discarded	1,217.00'	**0.240 in/hr Exfiltration over Surface area**

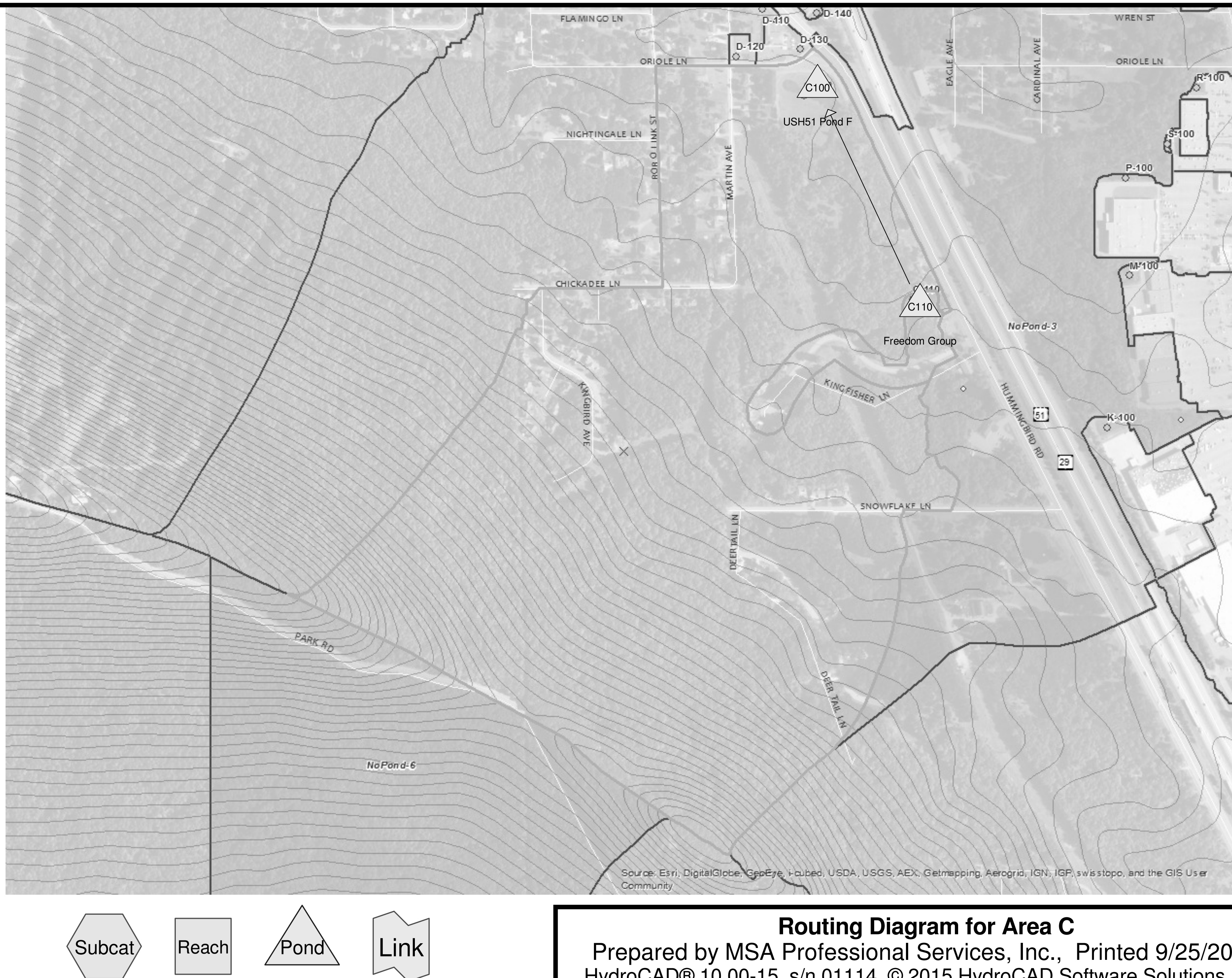
Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**5=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
├─**1=Beehive Casting** (Controls 0.00 cfs)
├─**3=Orifice/Grate** (Controls 0.00 cfs)
└─**4=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond B210: Dunkin Donuts





Routing Diagram for Area C

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Summary for Pond C100: USH51 Pond F

Pond data from WDOT plans dated 09-25-03
Outlet pipe diamter assumed to match downstream pipe (Plan notes indicate a weir plate and riser)

Inflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af	
Outflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af,	Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af	

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 1,191.00' @ 5.00 hrs Surf.Area= 0.305 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

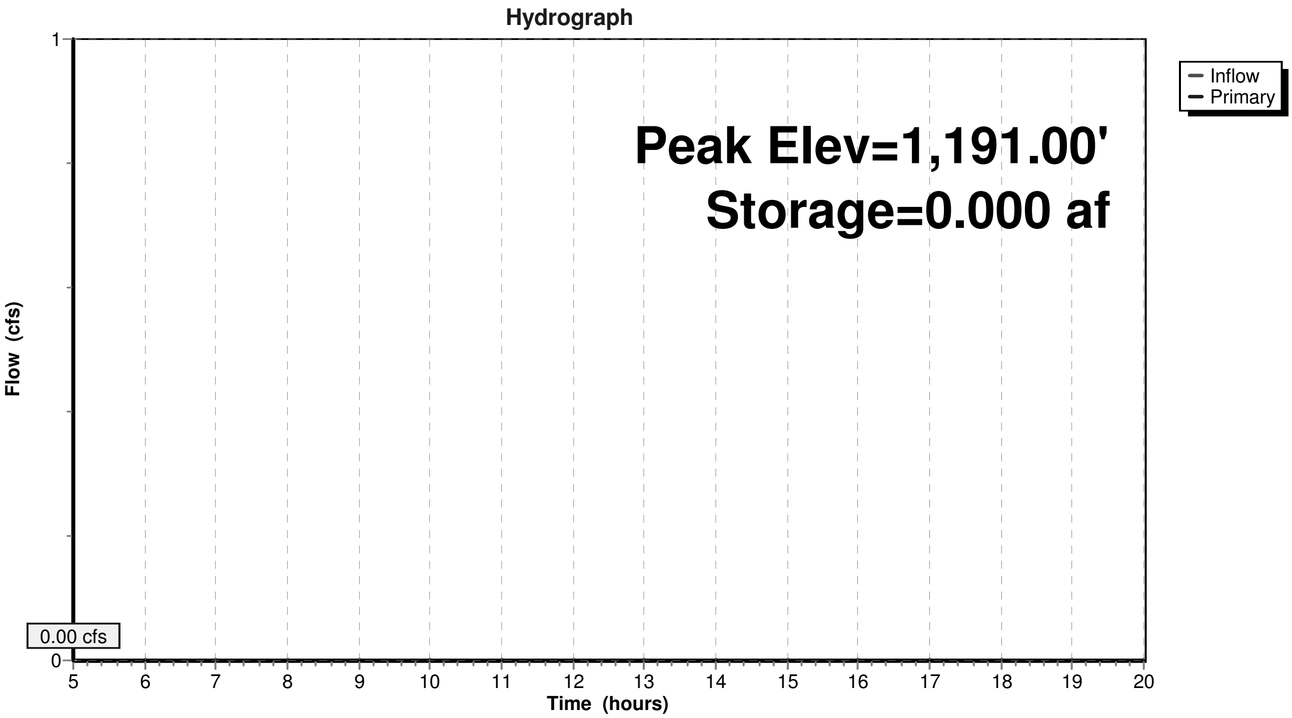
Volume	Invert	Avail.Storage	Storage Description
#1	1,191.00'	16.995 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,191.00	0.305	0.000	0.000
1,192.00	0.377	0.341	0.341
1,193.00	0.453	0.415	0.756
1,194.00	1.105	0.779	1.535
1,195.00	1.846	1.475	3.010
1,196.00	2.552	2.199	5.209
1,197.00	2.837	2.694	7.904
1,198.00	2.965	2.901	10.805
1,199.00	3.094	3.030	13.835
1,200.00	3.226	3.160	16.995

Device	Routing	Invert	Outlet Devices
#1	Primary	1,196.00'	**30.0" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,191.00' (Free Discharge)
└—**1=Orifice/Grate** (Controls 0.00 cfs)

Pond C100: USH51 Pond F



Summary for Pond C110: Freedom Group

Pond data from report by MTS dated 08-04, storage volume from included plans, outlet from included narrative.

[43] Hint: Has no inflow (Outflow=Zero)

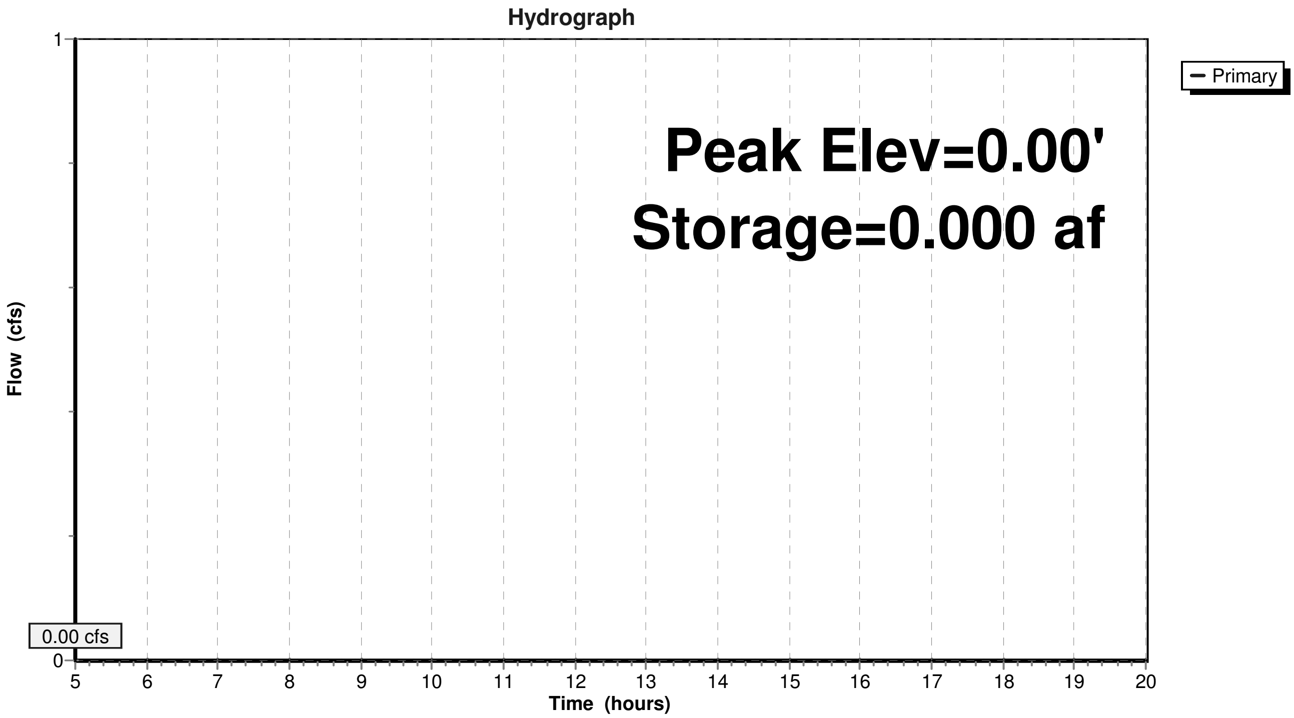
Volume	Invert	Avail.Storage	Storage Description
#1	1,212.00'	1.103 af	**Custom Stage Data (Prismatic)** Listed below

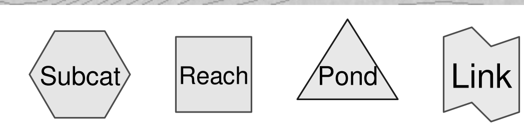
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,212.00	0.183	0.000	0.000
1,213.00	0.225	0.204	0.204
1,214.00	0.276	0.250	0.454
1,215.00	0.323	0.299	0.754
1,216.00	0.375	0.349	1.103

Device	Routing	Invert	Outlet Devices
#1	Primary	1,213.00'	**2.5" Vert. Orifice/Grate** C= 0.600
#2	Primary	1,214.00'	**6.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	1,215.00'	**24.0" x 36.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
1=Orifice/Grate (Controls 0.00 cfs)
2=Orifice/Grate (Controls 0.00 cfs)
3=Orifice/Grate (Controls 0.00 cfs)

Pond C110: Freedom Group





Routing Diagram for Area D

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Summary for Pond 1P: US51 Pond E

Inflow	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs, Volume=	0.003 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs, Volume=	0.003 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Starting Elev= 1,165.50' Surf.Area= 2.436 ac Storage= 8.949 af
Peak Elev= 1,165.50' @ 5.00 hrs Surf.Area= 2.436 ac Storage= 8.949 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	1,161.00'	26.542 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,161.00	1.732	0.000	0.000
1,162.00	1.835	1.784	1.784
1,163.00	1.940	1.887	3.671
1,164.00	2.049	1.994	5.665
1,165.00	2.200	2.124	7.790
1,165.50	2.436	1.159	8.949
1,166.00	2.671	1.277	10.226
1,167.00	2.911	2.791	13.017
1,168.00	3.154	3.033	16.049
1,169.00	3.401	3.277	19.327
1,170.00	3.652	3.526	22.853
1,171.01	3.652	3.689	26.542

Device	Routing	Invert	Outlet Devices
#1	Device 3	1,165.46'	**18.0" Vert. Orifice/Grate** C= 0.600
#2	Device 3	1,169.25'	**6.0' long x 1.67' rise Sharp-Crested Rectangular Weir** 2 End Contraction(s) 3.8' Crest Height
#3	Primary	1,165.46'	**24.0" Round Culvert** L= 400.0' Ke= 0.500 Inlet / Outlet Invert= 1,165.46' / 1,165.01' S= 0.0011 '/' Cc= 0.900 n= 0.013, Flow Area= 3.14 sf
#4	Primary	1,170.00'	**80.0' long x 20.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,165.50' (Free Discharge)
- **3=Culvert** (Barrel Controls 0.00 cfs @ 0.28 fps)
  - **1=Orifice/Grate** (Passes 0.00 cfs of 0.01 cfs potential flow)
  - **2=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)
- **4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond D110: Covantage Regional

Pond data from MSA report dated 07-07

Inflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Discarded	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af
Primary	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 1,193.00' @ 5.00 hrs Surf.Area= 0.004 ac Storage= 0.000 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	1,193.00'	1.581 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,193.00	0.004	0.000	0.000
1,194.00	0.018	0.011	0.011
1,196.00	0.056	0.074	0.085
1,197.00	0.323	0.189	0.274
1,198.00	0.397	0.360	0.634
1,199.00	0.473	0.435	1.069
1,200.00	0.551	0.512	1.581

Device	Routing	Invert	Outlet Devices
#1	Primary	1,194.90'	**48.0" Round Culvert** L= 210.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 1,194.90' / 1,193.55' S= 0.0064 '/' Cc= 0.900 n= 0.012, Flow Area= 12.57 sf
#2	Discarded	1,193.00'	**3.600 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,193.00' (Free Discharge)
↑**2=Exfiltration** (Passes 0.00 cfs of 0.01 cfs potential flow)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,193.00' (Free Discharge)
↑**1=Culvert** (Controls 0.00 cfs)

Summary for Pond D120: Covantage SW

Pond data from MSA report dated 07-07

Volume	Invert	Avail.Storage	Storage Description
#1	1,198.00'	0.378 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,198.00	0.021	0.000	0.000
1,199.00	0.097	0.059	0.059
1,200.00	0.171	0.134	0.193
1,201.00	0.200	0.185	0.378

Device	Routing	Invert	Outlet Devices
#1	Primary	1,198.65'	**12.0" Round Culvert** L= 140.0' CMP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 1,198.65' / 1,197.00' S= 0.0118 '/' Cc= 0.900 n= 0.024, Flow Area= 0.79 sf
#2	Secondary	1,200.00'	**250.0' long x 20.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#3	Discarded	1,198.00'	**3.600 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**3=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**1=Culvert** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond D130: Covantage SE

Pond data from MSA report dated 07-07

Volume	Invert	Avail.Storage	Storage Description
#1	1,197.00'	0.207 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,197.00	0.034	0.000	0.000
1,198.00	0.098	0.066	0.066
1,199.00	0.184	0.141	0.207

Device	Routing	Invert	Outlet Devices
#1	Primary	1,196.80'	**12.0" Round Culvert** L= 52.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,196.80' / 1,196.30' S= 0.0096 '/' Cc= 0.900 n= 0.013, Flow Area= 0.79 sf
#2	Secondary	1,198.50'	**125.0' long x 20.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#3	Discarded	1,197.00'	**3.600 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
↑—**3=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
↑—**1=Culvert** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
↑—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond D140: Szmanda Dental

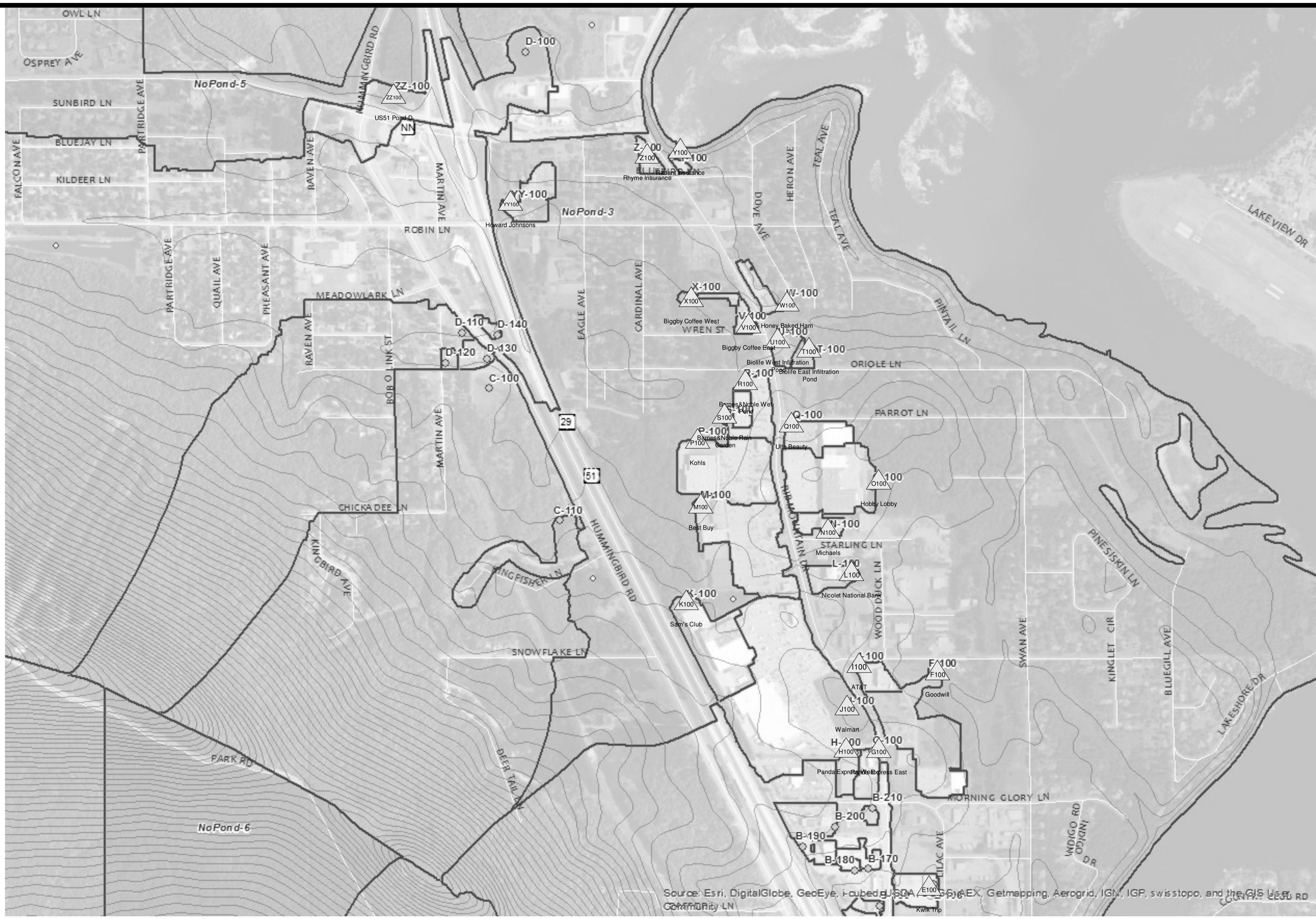
Pond data from modeling within report prepared by REI dated 08-27-07

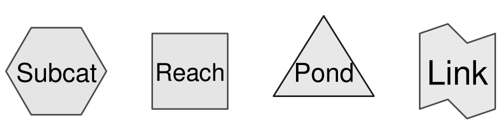
Volume	Invert	Avail.Storage	Storage Description
#1	1,196.00'	6,994 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,196.00	1,281	0	0
1,197.00	1,939	1,610	1,610
1,198.00	2,675	2,307	3,917
1,199.00	3,478	3,077	6,994

Device	Routing	Invert	Outlet Devices
#1	Device 3	1,196.00'	**2.0" Vert. Orifice/Grate** C= 0.600
#2	Device 3	1,198.76'	**90.0 deg x 4.0' long Sharp-Crested Vee/Trap Weir** Cv= 2.50 (C= 3.13)
#3	Primary	1,195.93'	**15.0" Round Culvert** L= 22.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 1,195.93' / 1,193.60' S= 0.1059 '/' Cc= 0.900 n= 0.012, Flow Area= 1.23 sf

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**3=Culvert** (Controls 0.00 cfs)
  ├─**1=Orifice/Grate** (Controls 0.00 cfs)
  └─**2=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)





Routing Diagram for Solo Ponds

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Summary for Pond E100: Kwik Trip

Pond data from model included in report by Sunde Engineering revised 07-09-13

Inflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs,	Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Starting Elev= 1,187.00' Surf.Area= 0.134 ac Storage= 0.258 af
Peak Elev= 1,187.00' @ 5.00 hrs Surf.Area= 0.134 ac Storage= 0.258 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

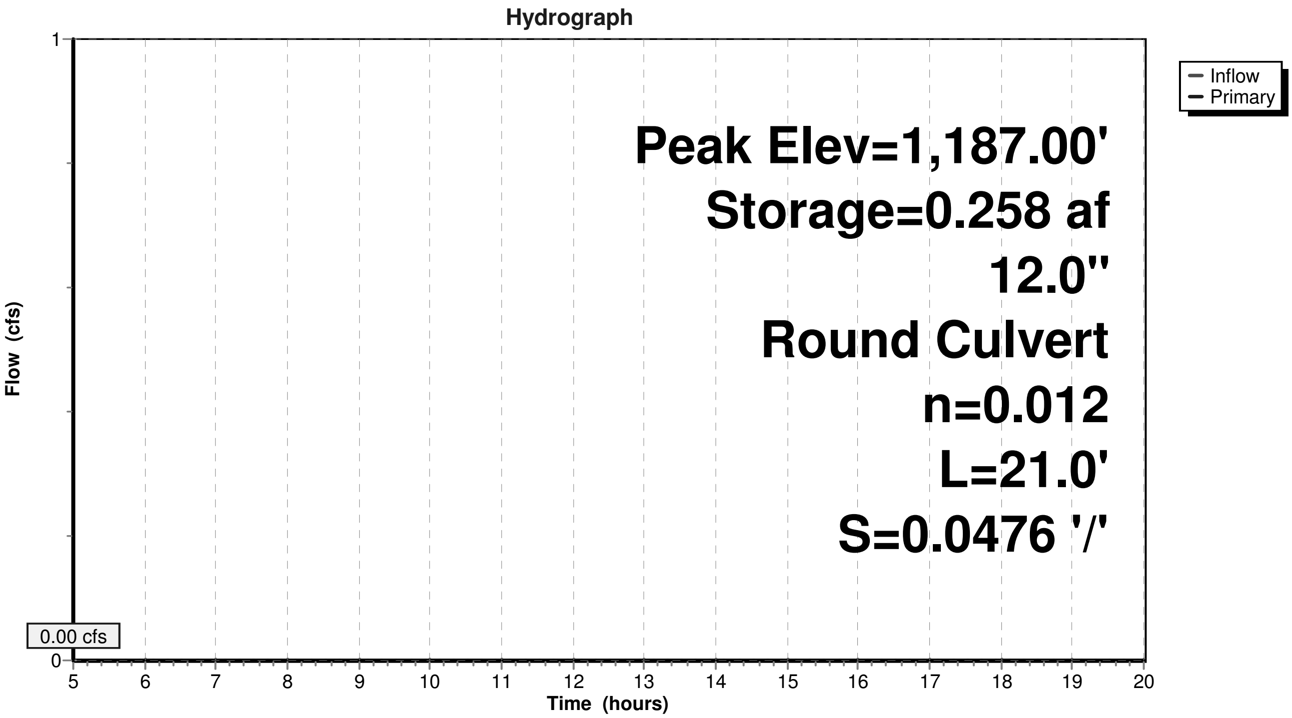
Volume	Invert	Avail.Storage	Storage Description
#1	1,182.00'	0.796 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,182.00	0.017	0.000	0.000
1,183.00	0.027	0.022	0.022
1,184.00	0.038	0.032	0.054
1,185.00	0.051	0.044	0.099
1,186.00	0.067	0.059	0.158
1,187.00	0.134	0.100	0.258
1,188.00	0.163	0.148	0.407
1,189.00	0.194	0.178	0.585
1,190.00	0.228	0.211	0.796

Device	Routing	Invert	Outlet Devices
#1	Primary	1,187.00'	**12.0" Round Culvert** L= 21.0' Ke= 0.500 Inlet / Outlet Invert= 1,187.00' / 1,186.00' S= 0.0476 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,187.00' (Free Discharge)
└─**1=Culvert** (Controls 0.00 cfs)

Pond E100: Kwik Trip



Summary for Pond F100: Goodwill

Pond riser and storage data for above NWL from report by Davel Engineering dated 10-06-10
Pond outlet (not riser - plan discrepancy) and storage data for below NWL from plans by Davel Engineering dated 07-15-10

Inflow	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Starting Elev= 1,199.50' Surf.Area= 18,950 sf Storage= 66,185 cf
Peak Elev= 1,199.50' @ 5.00 hrs Surf.Area= 18,950 sf Storage= 66,185 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

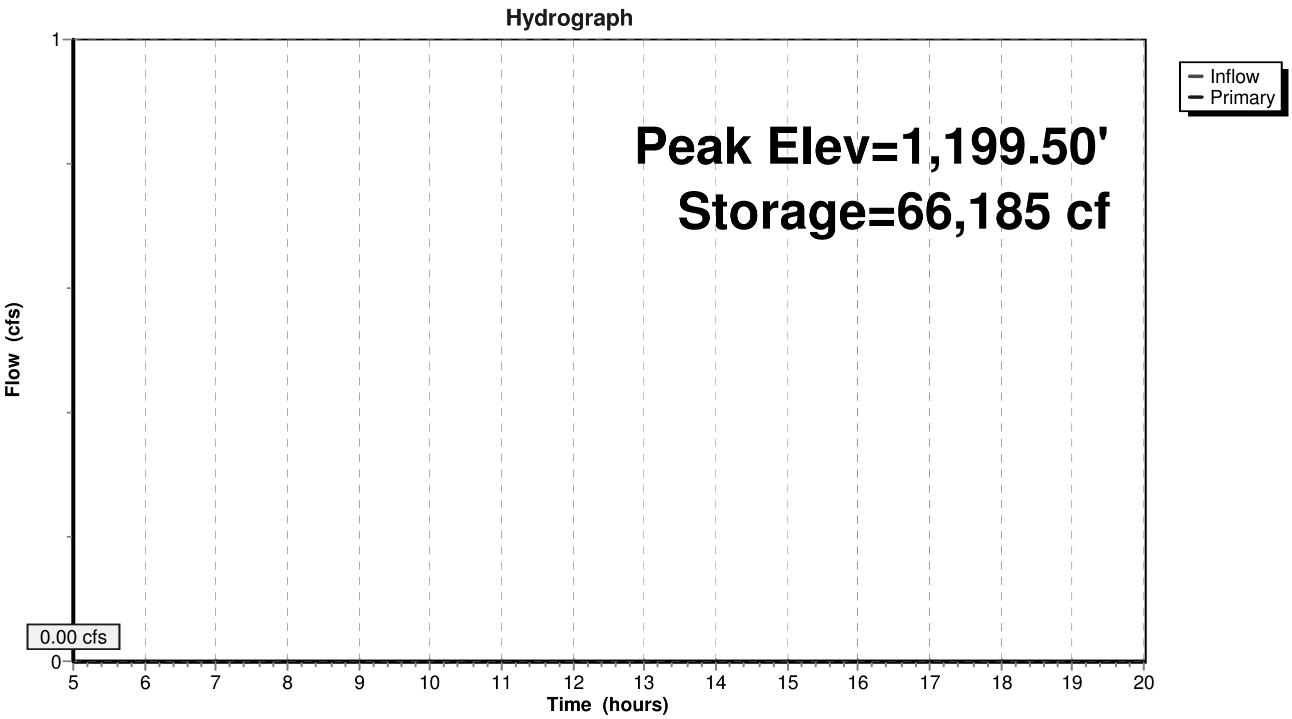
Volume	Invert	Avail.Storage	Storage Description
#1	1,194.00'	121,427 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,194.00	8,016	0	0
1,195.00	8,819	8,418	8,418
1,196.00	9,649	9,234	17,652
1,197.00	10,506	10,078	27,729
1,198.00	15,192	12,849	40,578
1,199.50	18,950	25,607	66,185
1,200.00	20,066	9,754	75,939
1,201.00	22,370	21,218	97,157
1,202.00	26,170	24,270	121,427

Device	Routing	Invert	Outlet Devices
#1	Device 3	1,199.50'	**6.0" Round Culvert** L= 6.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 1,199.50' / 1,199.00' S= 0.0833 '/' Cc= 0.900 n= 0.011, Flow Area= 0.20 sf
#2	Device 3	1,200.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	1,199.00'	**10.0" Round Culvert** L= 16.0' Ke= 0.200 Inlet / Outlet Invert= 1,199.00' / 1,198.84' S= 0.0100 '/' Cc= 0.900 n= 0.013, Flow Area= 0.55 sf
#4	Primary	1,201.00'	**20.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,199.50' (Free Discharge)
└─**3=Culvert** (Passes 0.00 cfs of 0.74 cfs potential flow)
  ├─**1=Culvert** (Controls 0.00 cfs)
  └─**2=Orifice/Grate** (Controls 0.00 cfs)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond F100: Goodwill



Summary for Pond G100: Panda Express East

Stormwater plan by Olsson Associates dated 10-28-14 does not contain sufficient information to describe pond volume or outlet.

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[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond H100: Panda Express West

Stormwater plan by Olsson Associates dated 10-28-14 does not contain sufficient information to describe pond volume or outlet.

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond I100: AT&T

Pond (dry) data from report by Point of Beginning dated 05-29-07. The report states that water quality treatment (40% TSS reduction) is achieved through grass fillter strips, catch basin sumps and infiltration basins. WinSLAMM model results are provided showing 40.93% TSS reduction, but no input is provided describing practices.

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[43] Hint: Has no inflow (Outflow=Zero)

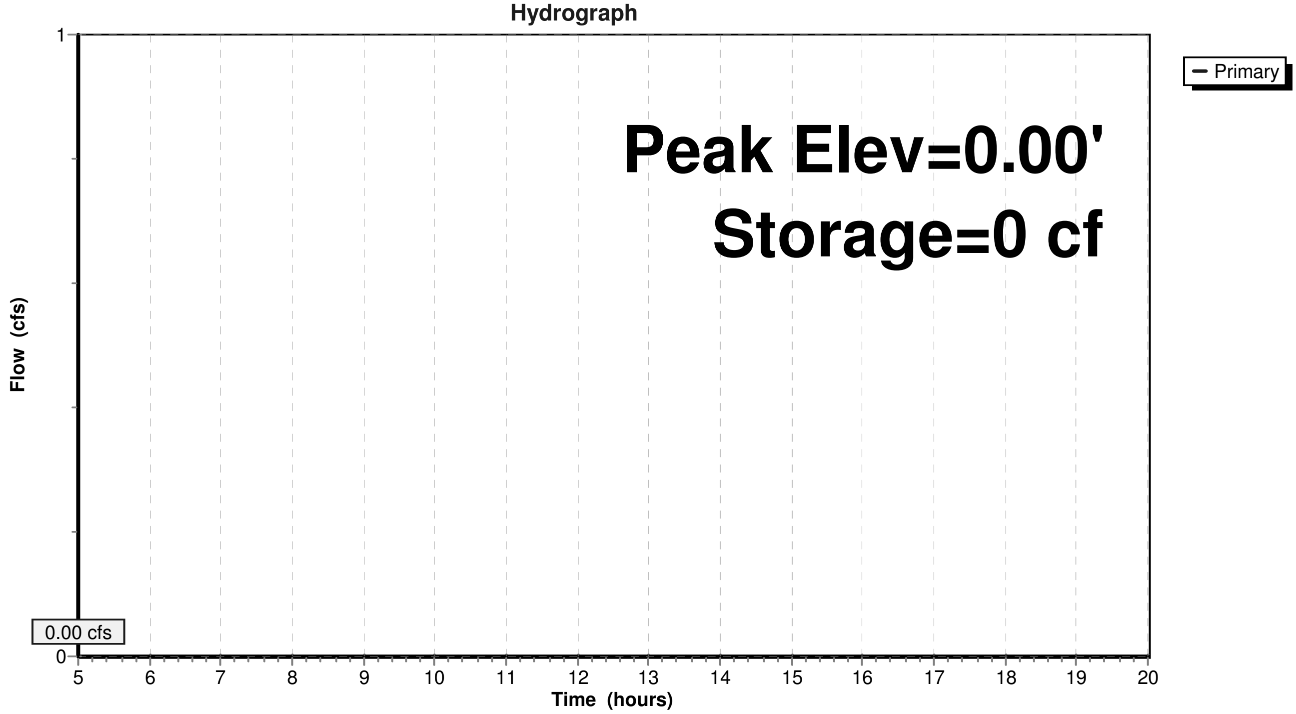
Volume	Invert	Avail.Storage	Storage Description
#1	1,205.00'	6,888 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,205.00	674	0	0
1,206.00	1,165	920	920
1,207.00	1,727	1,446	2,366
1,208.00	2,423	2,075	4,441
1,209.01	2,423	2,447	6,888

Device	Routing	Invert	Outlet Devices
#1	Device 2	1,205.00'	**18.0" Round Culvert** L= 6.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 1,205.00' / 1,205.00' S= 0.0000 '/' Cc= 0.900 n= 0.013, Flow Area= 1.77 sf
#2	Device 4	1,205.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 1.44 1.45 2.09 2.10 2.24 2.25 3.00 Width (feet) 0.57 0.57 1.11 1.11 2.56 2.56 3.00 3.00
#3	Device 4	1,208.00'	**36.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#4	Primary	1,205.00'	**18.0" Round Culvert** L= 6.0' Ke= 0.200 Inlet / Outlet Invert= 1,205.00' / 1,205.00' S= 0.0000 '/' Cc= 0.900 n= 0.013, Flow Area= 1.77 sf

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**4=Culvert** (Controls 0.00 cfs)
  ├─**2=Custom Weir/Orifice** (Controls 0.00 cfs)
  │ └─**1=Culvert** (Controls 0.00 cfs)
  └─**3=Orifice/Grate** (Controls 0.00 cfs)

Pond I100: AT&T



Summary for Pond J100: Walmart

No Plans

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[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond K100: Sam's Club

No Plans

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond L100: Nicolet National Bank

No Plans

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond M100: Best Buy

No Plans

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond N100: Michaels

No Plans

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond O100: Hobby Lobby

No Plans

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond P100: Kohls

Pond data from storwmater management plan report by REI dated 03-09-00

[43] Hint: Has no inflow (Outflow=Zero)

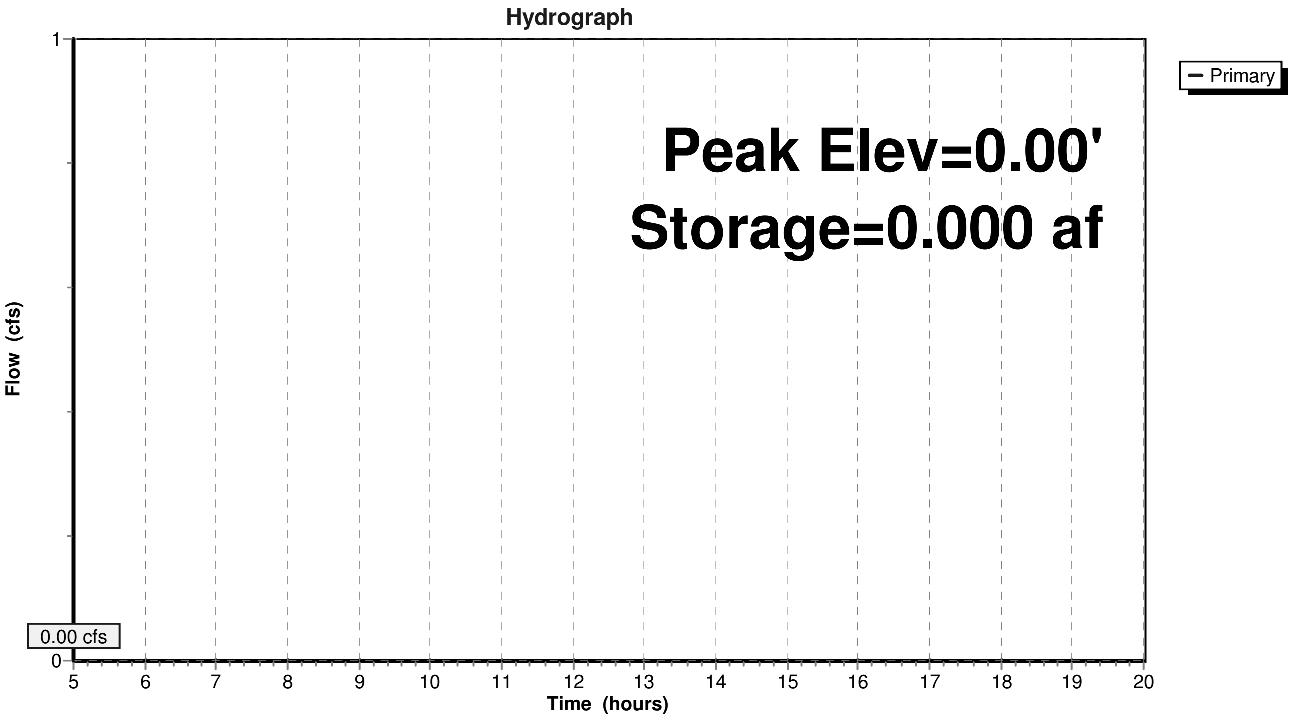
Volume	Invert	Avail.Storage	Storage Description
#1	1,193.00'	2.016 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,193.00	0.049	0.000	0.000
1,194.00	0.074	0.061	0.061
1,195.00	0.101	0.087	0.149
1,196.00	0.131	0.116	0.265
1,197.00	0.163	0.147	0.412
1,198.00	0.197	0.180	0.592
1,199.00	0.234	0.215	0.807
1,200.00	0.269	0.251	1.059
1,201.00	0.302	0.286	1.344
1,202.00	0.336	0.319	1.663
1,203.00	0.370	0.353	2.016

Device	Routing	Invert	Outlet Devices
#1	Device 3	1,195.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#2	Device 3	1,201.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	1,194.00'	**12.0" Round Culvert** L= 31.0' Ke= 0.200 Inlet / Outlet Invert= 1,194.00' / 1,193.50' S= 0.0161 '/' Cc= 0.900 n= 0.024, Flow Area= 0.79 sf
#4	Device 6	1,195.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#5	Device 6	1,201.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#6	Primary	1,194.00'	**12.0" Round Culvert** L= 31.0' Ke= 0.200 Inlet / Outlet Invert= 1,194.00' / 1,193.50' S= 0.0161 '/' Cc= 0.900 n= 0.024, Flow Area= 0.79 sf
#7	Primary	1,202.00'	**5.0' long x 3.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 Coef. (English) 2.44 2.58 2.68 2.67 2.65 2.64 2.64 2.68 2.68 2.72 2.81 2.92 2.97 3.07 3.32

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
- **3=Culvert** (Controls 0.00 cfs)
  - **1=Orifice/Grate** (Controls 0.00 cfs)
  - **2=Orifice/Grate** (Controls 0.00 cfs)
- **6=Culvert** (Controls 0.00 cfs)
  - **4=Orifice/Grate** (Controls 0.00 cfs)
  - **5=Orifice/Grate** (Controls 0.00 cfs)
- **7=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond P100: Kohls



Summary for Pond Q100: Ulta Beauty

Pond data from stormwater management plan report by Harris and Associates, Inc. dated 11-23-11

Inflow	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af
Outflow	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af, Atten= 0%, Lag= 0.0 min
Primary	=	0.00 cfs @	5.00 hrs, Volume=	0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Starting Elev= 1,203.00' Surf.Area= 0.081 ac Storage= 0.111 af
Peak Elev= 1,203.00' @ 5.00 hrs Surf.Area= 0.081 ac Storage= 0.111 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no inflow)

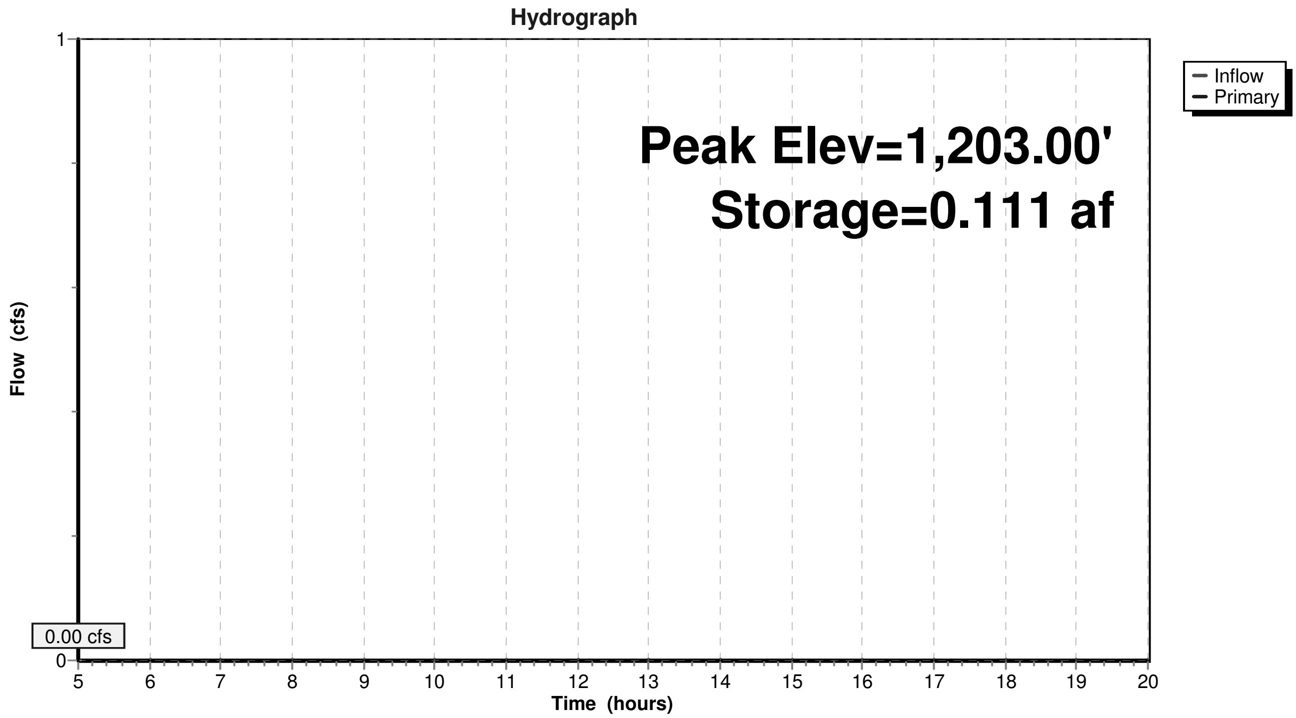
Volume	Invert	Avail.Storage	Storage Description
#1	1,199.50'	0.962 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,199.50	0.000	0.000	0.000
1,200.00	0.013	0.003	0.003
1,201.00	0.024	0.018	0.022
1,202.00	0.037	0.030	0.052
1,203.00	0.081	0.059	0.111
1,204.00	0.100	0.091	0.202
1,205.00	0.120	0.110	0.312
1,206.00	0.140	0.130	0.442
1,207.00	0.160	0.150	0.592
1,208.00	0.190	0.175	0.767
1,209.00	0.200	0.195	0.962

Device	Routing	Invert	Outlet Devices
#1	Primary	1,203.00'	**2.5" Vert. Orifice/Grate** C= 0.600
#2	Primary	1,206.00'	**7.0" Vert. Orifice/Grate** C= 0.600
#3	Primary	1,207.90'	**12.0" Vert. Orifice/Grate X 3.00** C= 0.600

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=1,203.00' (Free Discharge)
├─**1=Orifice/Grate** (Controls 0.00 cfs)
├─**2=Orifice/Grate** (Controls 0.00 cfs)
└─**3=Orifice/Grate** (Controls 0.00 cfs)

Pond Q100: Ulta Beauty



Summary for Pond R100: Barnes&Noble Wet Pond

No Plans

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond S100: Barnes&Noble Rain Garden

No Plans

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond T100: Biolife East Infiltration Pond

Pond data from stormwater management plan report by Excel Engineering dated 06-18-14

[43] Hint: Has no inflow (Outflow=Zero)

Volume	Invert	Avail.Storage	Storage Description
#1	1,188.55'	6,711 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

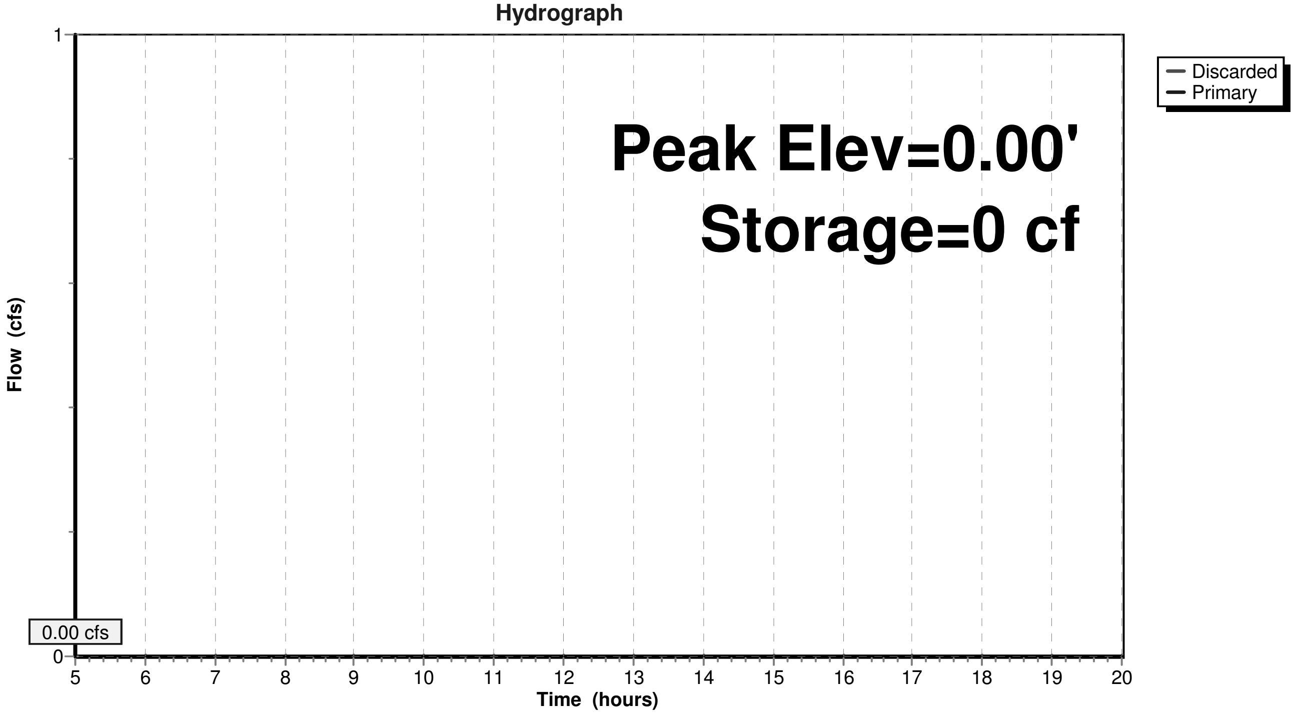
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,188.55	1,785	0	0
1,189.00	2,115	878	878
1,190.00	3,682	2,899	3,776
1,190.65	5,350	2,935	6,711

Device	Routing	Invert	Outlet Devices
#1	Discarded	1,188.55'	**3.600 in/hr Exfiltration over Surface area**
#2	Primary	1,190.45'	**10.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**1=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond T100: Biolife East Infiltration Pond



Summary for Pond U100: Biolife West Infiltration Pond

Pond data from stormwater management plan report by Excel Engineering dated 06-18-14

[43] Hint: Has no inflow (Outflow=Zero)

Volume	Invert	Avail.Storage	Storage Description
#1	1,188.50'	15,852 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

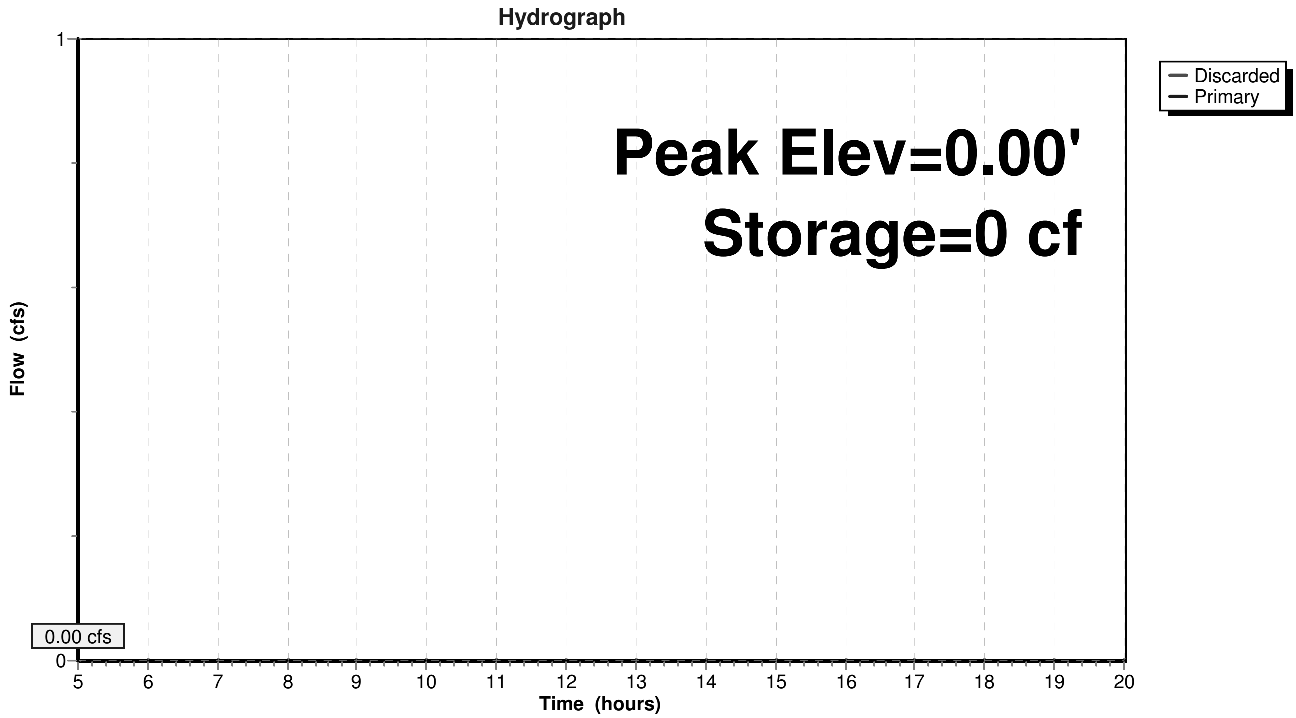
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,188.50	3,875	0	0
1,189.00	4,535	2,103	2,103
1,190.00	6,971	5,753	7,856
1,191.00	9,021	7,996	15,852

Device	Routing	Invert	Outlet Devices
#1	Discarded	1,188.50'	**3.600 in/hr Exfiltration over Surface area**
#2	Primary	1,190.25'	**10.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**1=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond U100: Biolife West Infiltration Pond



Summary for Pond V100: Biggby Coffee East

Pond data from modeling within stormwater management plan report by MTS dated 05-13-04

[43] Hint: Has no inflow (Outflow=Zero)

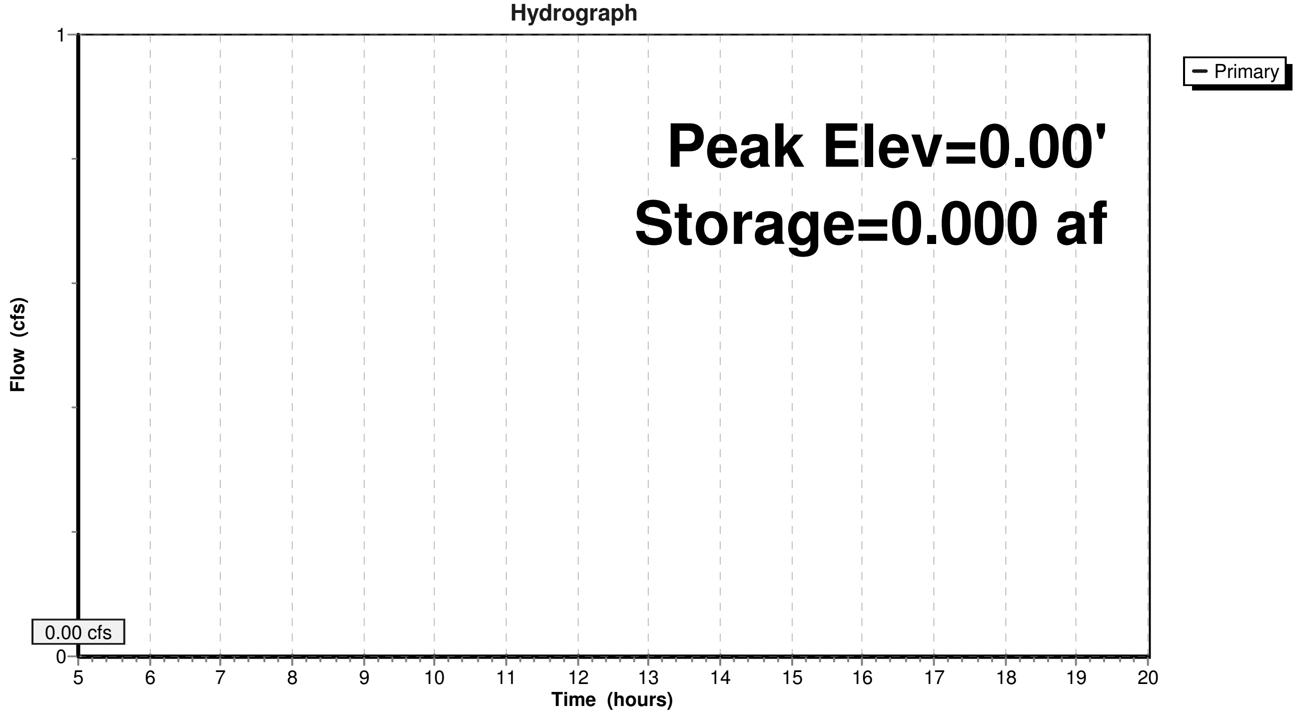
Volume	Invert	Avail.Storage	Storage Description
#1	1,184.00'	0.133 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
1,184.00	0.000
1,184.50	0.007
1,185.00	0.016
1,185.50	0.028
1,186.00	0.043
1,186.50	0.061
1,187.00	0.084
1,187.50	0.110
1,187.90	0.133

Device	Routing	Invert	Outlet Devices
#1	Primary	1,184.00'	**Special & User-Defined** Head (feet) 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 3.90 Disch. (cfs) 0.000 0.300 0.300 0.400 0.400 0.700 0.800 0.900 0.900

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**1=Special & User-Defined** (Controls 0.00 cfs)

Pond V100: Biggby Coffee East



Summary for Pond W100: Honey Baked Ham

Pond data from stormwater management plan report by REI dated 05-15-07

[43] Hint: Has no inflow (Outflow=Zero)

Volume	Invert	Avail.Storage	Storage Description
#1	1,184.00'	23,373 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

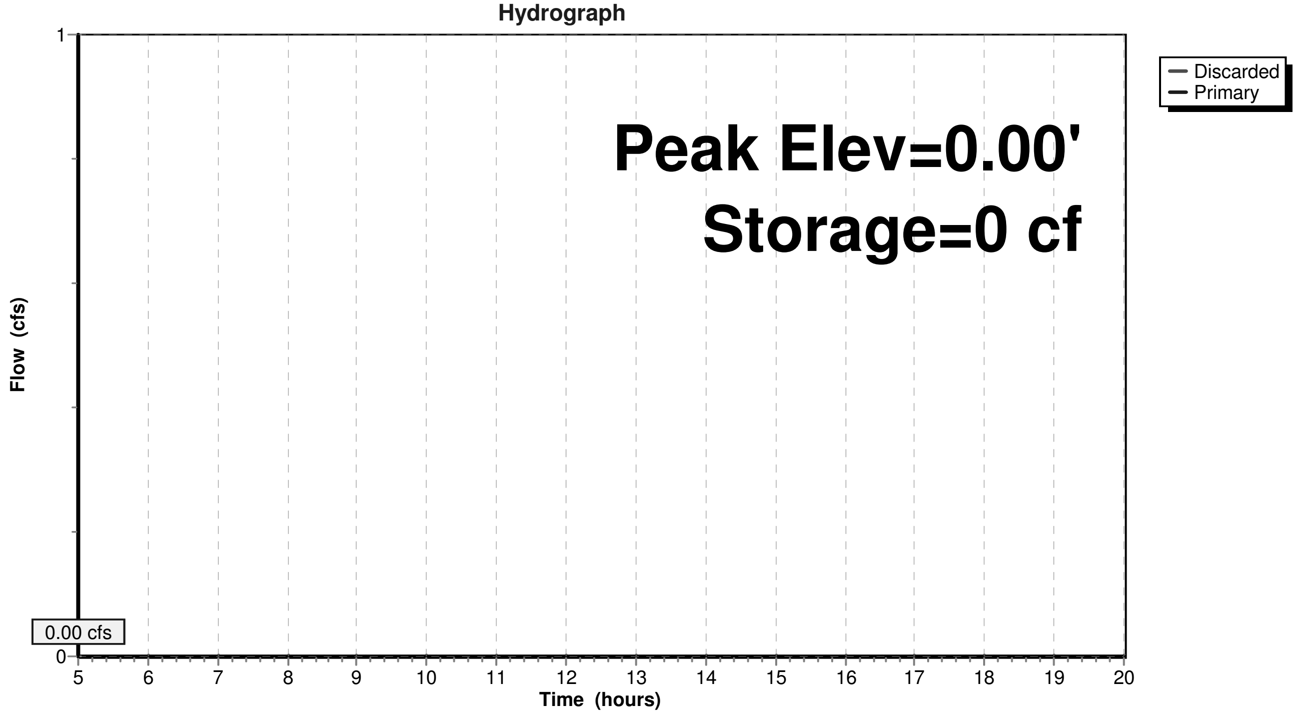
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,184.00	843	0	0
1,185.00	2,636	1,740	1,740
1,186.00	6,685	4,661	6,400
1,187.00	8,455	7,570	13,970
1,188.00	10,350	9,403	23,373

Device	Routing	Invert	Outlet Devices
#1	Discarded	1,184.00'	**1.656 in/hr Exfiltration over Surface area**
#2	Primary	1,187.00'	**6.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**1=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond W100: Honey Baked Ham



Summary for Pond X100: Biggby Coffee West

Pond data from modeling within stormwater management plan report by MTS dated 05-13-04

[43] Hint: Has no inflow (Outflow=Zero)

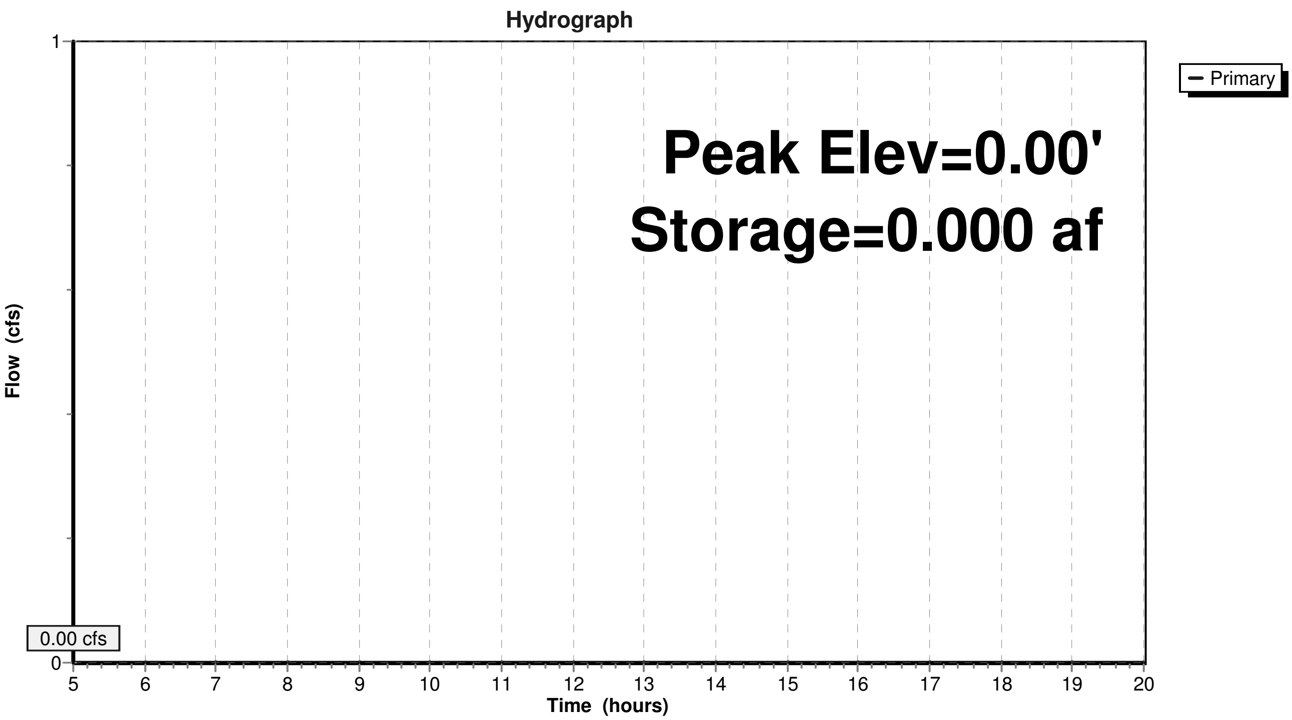
Volume	Invert	Avail.Storage	Storage Description
#1	1,185.00'	0.157 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
1,185.00	0.000
1,185.50	0.033
1,186.00	0.072
1,186.50	0.117
1,186.90	0.157

Device	Routing	Invert	Outlet Devices
#1	Primary	1,185.00'	**Special & User-Defined** Head (feet) 0.00 0.10 0.50 1.00 1.50 1.90 Disch. (cfs) 0.000 0.100 0.300 0.300 0.700 0.700

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**1=Special & User-Defined** (Controls 0.00 cfs)

Pond X100: Biggby Coffee West



Summary for Pond Y100: Radant Insurance

No Plans

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[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond YY100: Howard Johnsons

Incomplete stormwater plan

[40] Hint: Not Described (Outflow=Inflow)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=0.00' TW=0.00' (Free Discharge)

Summary for Pond Z100: Rhyme Insurance

Pond data from stormwater management plan report by Jeff Babl dated 02-05. Some inconsistencies between modeling and plans. Orifice outlet added per plans.

[43] Hint: Has no inflow (Outflow=Zero)

Volume	Invert	Avail.Storage	Storage Description
#1	1,184.00'	4,382 cf	**ADS_StormTech DC-780** x 94.76 Inside #2 Effective Size= 45.4"W x 30.0"H => 6.49 sf x 7.12'L = 46.2 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
#2	1,183.50'	4,784 cf	**30.00'W x 116.00'L x 4.00'H Prismatoid Z=1.0** 16,341 cf Overall - 4,382 cf Embedded = 11,960 cf x 40.0% Voids
#3	1,188.60'	2,506 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)
		11,672 cf	Total Available Storage

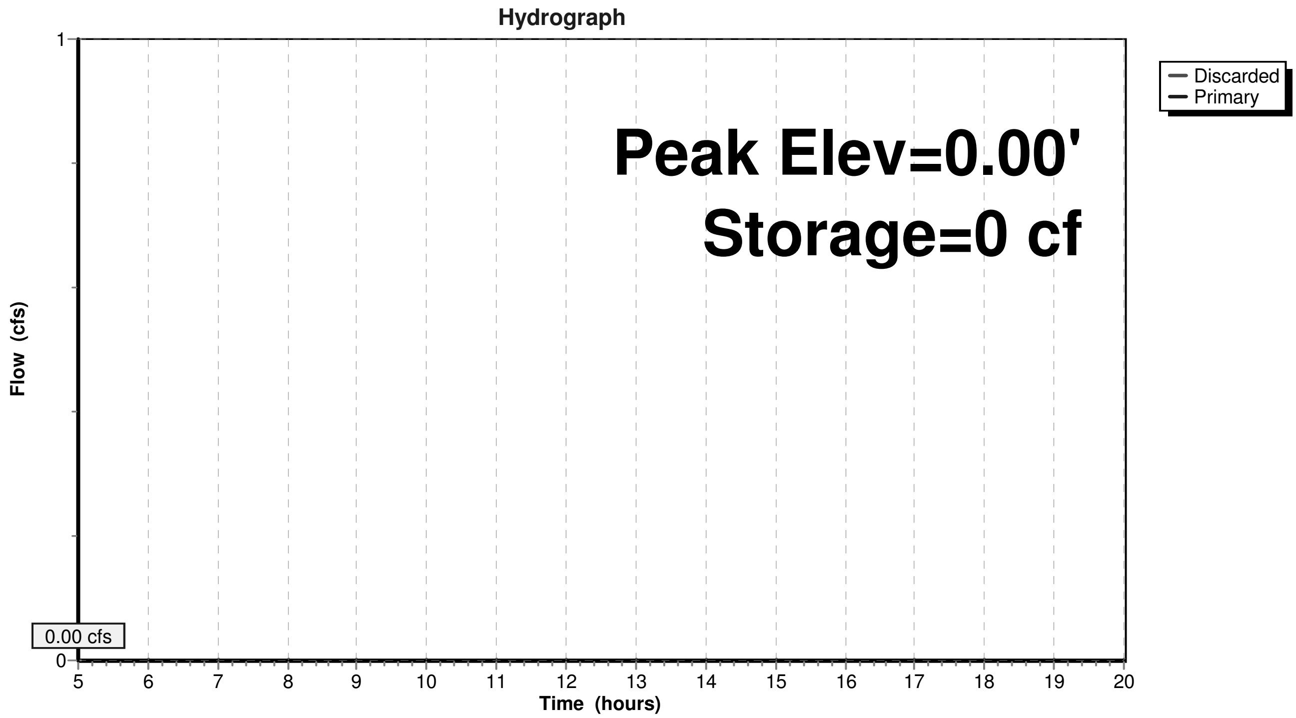
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
1,188.60	0	0	0
1,189.10	3,094	774	774
1,189.50	5,570	1,733	2,506

Device	Routing	Invert	Outlet Devices
#1	Discarded	1,183.50'	**3.600 in/hr Exfiltration over Horizontal area**
#2	Primary	1,186.01'	**6.6" Vert. Orifice/Grate** C= 0.600

Discarded OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**1=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Pond Z100: Rhyme Insurance



Summary for Pond ZZ100: US51 Pond D

Pond data from DOT plans dated 09/25/03

[43] Hint: Has no inflow (Outflow=Zero)

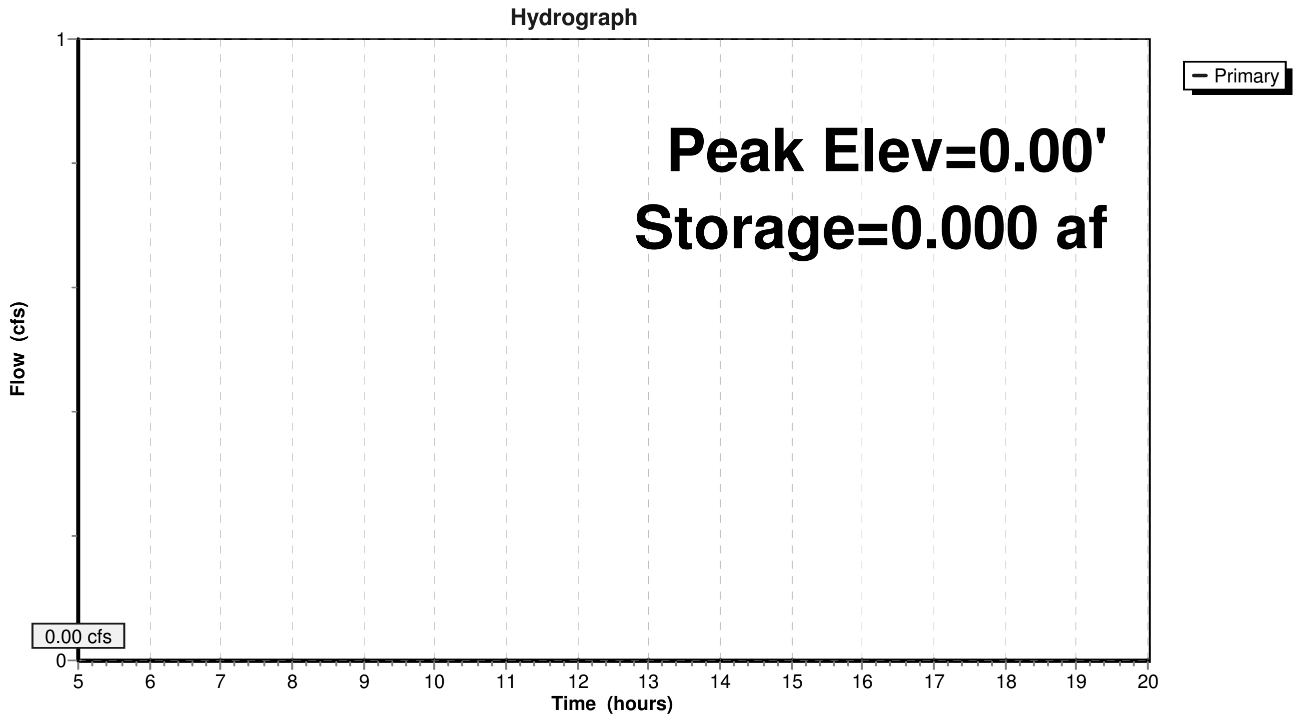
Volume	Invert	Avail.Storage	Storage Description
#1	1,172.00'	4.007 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,172.00	0.832	0.000	0.000
1,173.00	0.914	0.873	0.873
1,174.00	0.995	0.954	1.827
1,176.00	1.185	2.180	4.007

Device	Routing	Invert	Outlet Devices
#1	Primary	1,173.00'	**Gabion** Head (feet) 0.00 1.00 2.00 3.00 4.00 5.00 6.00 Disch. (cfs) 0.000 1.300 3.700 6.800 10.500 14.700 19.300
#2	Primary	1,175.00'	**50.0' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=0.00' (Free Discharge)
├─**1=Gabion** (Controls 0.00 cfs)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond ZZ100: US51 Pond D



APPENDIX D

WDNR Modeling Guidance

BUREAU OF WATERSHED MANAGEMANT
PROGRAM GUIDANCE

Storm Water Management Program

TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance

Effective: October 20, 2014
Guidance #: 3800-2014-04

Notice: This document is intended solely as guidance, and does not contain any mandatory requirements except where requirements found in statute or administrative rule are referenced. This guidance does not establish or affect legal rights or obligations, and is not finally determinative of any of the issues addressed. This guidance does not create any rights enforceable by any party in litigation with the State of Wisconsin or the Department of Natural Resources. Any regulatory decisions made by the Department of Natural Resources in any matter addressed by this guidance will be made by applying the governing statutes and administrative rules to the relevant facts.

APPROVED:

Pam Biersach

Pam Biersach, Director
Bureau of Watershed Management

10/28/14
Date

A. Statement of Problem

The U.S. Environmental Protection Agency (EPA) requires the wasteload allocations (WLAs) developed as part of a Total Maximum Daily Load (TMDL) be reflected and implemented through permits. In Wisconsin, storm water discharge permits are issued pursuant to ch. NR 216, Wis. Adm. Code. As part of the TMDL process, permitted Municipal Separate Storm Sewer Systems (MS4s) are assigned individual TMDL WLAs. The placement of the WLA in a storm water permit can create numerous challenges including defining the municipal area encompassed by the WLA and modeling conditions to which the storm water WLA is to be applied. Department staff, municipal officials and storm water management plan developers need guidance to clarify how assessment of permit compliance with a WLA is to be demonstrated.

B. Background

A TMDL quantifies the amount of pollution that a waterbody can assimilate and still meet water quality standards. EPA requires that waters listed as impaired on Wisconsin's 303-d list have TMDLs developed. At a minimum, TMDLs must allocate the assimilative capacity between the load allocation, the WLA, and a margin of safety. The WLA is the portion of the assimilative capacity that is allocated to point sources. Nonpoint sources receive load allocations (LAs). WLAs are established for continuous point source discharges and also intermittent pollutant releases such as permitted storm water discharges.

Establishing WLAs for storm water sources requires an understanding of under what flow conditions impairments occur, and how storm water discharges are contributing to the identified impairments. Establishing WLAs for storm water sources also requires an understanding of exactly where the discharges are occurring. In many cases, municipal separate storm sewer systems (MS4s) have multiple discharge points that can be located in more than one reachshed[1]. In a TMDL, WLAs are assigned for each pollutant of concern and by reach. In a TMDL a MS4 can have multiple and different pollutant reduction goals within its municipal jurisdiction.

C. Discussion

Once EPA has approved a TMDL that contains permitted MS4s, the next permit issued must contain an expression of the WLAs consistent with the assumptions and requirements contained in the TMDL. As part of the TMDL process EPA approves the WLAs and generally these WLAs are mirrored directly in the permit. While this seems like a relatively straight forward permit process, the direct application of the WLA can present certain challenges in implementation due to assumptions required during the development of the TMDL. These assumptions revolve around aerial extent of the MS4 and its boundary, incorporation of new areas and expansion of the municipal boundary, and modeling differences between the tools used to create the TMDL versus the compliance tools used by the MS4. In addition, permitted MS4s have already performed municipal wide analysis to comply with requirements stipulated in ch. NR 151.13, Wis. Adm. Code. These requirements expressed reduction goals as a percent reduction from a defined no controls scenario with defined climate records.

[1] Reachsheds are also referred to as subwatersheds or segment sheds in TMDL development. A reach is a stream segment or individual lake or reservoir that is artificially assigned a compliance point or "pour point" where the applicable in-stream water quality standards must be met. Breaks for stream reaches are made at changes in stream listing (each individually named 303(d) water must have their own set of TMDLs), changes in water quality criteria, and at pour points or compliance points just upstream of significant changes in flow/assimilative capacity.

To build on established methodologies contained in s. NR 151.13, DNR's preferred option for implementing TMDLs is using a percent reduction methodology similar to s. NR 151.13. The use of a percent reduction strategy will utilize reduction goals consistent with the TMDL and allow implementation to continue to build on the same percent reduction strategy employed in s. NR 151.13 using the same models and tools that MS4s have already been utilizing. Since EPA only approves the WLA and not the corresponding percent reduction it is important that the TMDL reports and permit fact sheets, as appropriate, highlight that the percent reductions being used for implementation are consistent with the approved WLAs in the TMDL.

The usage of a percent reduction framework for implementation allows both the MS4 and DNR the ability to implement the reductions without having to reallocate and track WLAs across reachsheds, MS4s, and other land uses. This will minimize the need to continually update the TMDL as municipal boundaries evolve and ease reporting requirements. In some rare cases allocations may need to be adjusted. This is discussed in Attachment A.

D. Guidance

This document divides DNR's guidance for implementing TMDL WLAs for permitted MS4s into three parts:

- **Part 1** – Expressing WLAs and Reduction Targets
- **Part 2** – Implementation and Compliance Benchmarks
- **Part 3** – Modeling

PART 1 – Expressing WLAs and Reduction Targets

An MS4 will have a WLA for each pollutant of concern addressed by the TMDL. Generally the pollutant of concern for TMDLs in Wisconsin include total suspended solids (TSS) and total phosphorus (TP); however, allocations for other pollutants such as bacteria or chlorides are possible depending on what pollutants are causing impairments to surface waters.

Unlike the requirements contained in s. NR 151.13, individual MS4s may be divided in multiple reachsheds. As such, MS4s may have multiple WLAs and percent reductions instead of the uniform municipal wide percent reduction employed in s. NR 151.13. Multiple WLAs and percent reductions are the result of needing to meet water quality requirements for all water bodies and account for changes in water body type, changes in water quality criteria or targets, changes in flow, changes in designated use, and other similar factors. Compliance with TMDL requirements will need to be achieved on a reach by reach basis.

Due to the complexity of natural systems, the WLAs identified in the TMDL are the best estimate for meeting water quality standards and are modeled or simulated predictions. Initial implementation of the TMDL will be in most cases by design using SLAMM, P-8, or equivalent methodologies to estimate and track pollutant reductions. The MS4 is typically not required to perform ambient monitoring to assess if water quality standards are being met, but MS4s do need to track implementation activities and reductions achieved, and report on TMDL implementation in MS4 annual reports. Once an adequate level of implementation has been achieved, ambient monitoring can be used to judge progress and monitoring will ultimately be needed to de-list impaired waters and show compliance with the TMDL.

During the first term of an MS4 permit, after EPA approval of a TMDL, DNR will request that each permitted MS4 report its actual MS4 area served within each reachshed. Existing MS4 permittees should already have sewershed mapping completed to satisfy previous MS4 permit conditions and this should be used to verify the current MS4 area served within each reachshed. The Department will provide the GIS data sets used for the TMDL reachshed boundaries through its website. The main reasons for reporting this information are to determine if the MS4 area served by each permittee corresponds to each other and does not overlap or omit MS4 service areas and to provide a detailed accounting of MS4 areas and responsible parties.

In most TMDLs, non-traditional MS4s such as permitted universities and state and county highway facilities were not given unique WLAs and these areas will need to be identified. In addition, most TMDLs are not able to account for modifications in drainage due to manmade conveyance systems such as storm sewers. These modifications may require modification of reachshed boundaries. To account for this, the MS4 permit (MS4 General Permit see section 1.5.4.3) will require that permittees submit information to the DNR to verify appropriate boundaries and areas. To accomplish this DNR will require the following information:

- Updated storm sewer system map that identifies:
    - The current municipal boundary/permitted area. For city and village MS4s, identify the current municipal boundary. For MS4s that are not a city or village, identify its permitted area. The permitted area for towns, counties and non-traditional MS4s pertains to the area within the Urbanized Area of the 2010 Decennial Census.
    - The TMDL reachshed boundaries within the municipal boundary, and the area in acres of each TMDL reachshed within the municipal boundary.
    - The MS4 drainage area boundary associated with each TMDL reachshed, and the area in acres of the MS4 drainage area associated with each TMDL reachshed.
- Identification of areas on a map and the acreage of those areas within the municipal boundary that the permittee believes should be excluded from its analysis to show compliance with its WLA (see “WLA Analysis Area” in Part 3 of this document”). In addition, the permittee shall provide an explanation of why each area identified should not be its responsibility.
  Note: This information is to be acquired by the DNR through an MS4 annual report.

DNR will evaluate this information and consider whether modifications to the TMDL are warranted. It is common for TMDL derived MS4 areas and reachsheds to deviate from the actual MS4 drainage areas. Such deviations can have an impact on the TMDL; however in most cases, these deviations will not have a significant effect on the calculated percent reduction needed to meet the TMDL allocations.

To assist in understanding allocations the TMDLs developed in Wisconsin have in many cases expressed reduction goals in both a WLA format (a load expressed as a mass) and a percent reduction format. The percent reduction is calculated from the baseline condition used in the TMDL to quantify what is needed to meet water quality standards. During the development of the TMDLs, the percent reduction is calculated using the following equation:

Percent Reduction (from baseline) = 100 * (1 – (WLA Loading Condition / Baseline Loading Condition))

The baseline loading condition should be described in the TMDL. While there is some variation across TMDLs in Wisconsin, the baseline loading condition should reflect the regulatory conditions stipulated in s. NR 151.13 and utilize either the 20% TSS control requirement or the 40% TSS control requirement as the starting point for TMDL allocations. This is because TMDLs are required, at a minimum, to meet existing regulatory requirements.

In 2011, the Wisconsin Legislature approved Act 32 which prohibited the Department from enforcing the 40% TSS reduction contained in s. NR 151.13, Wis. Adm. Code. As such, TMDLs under development and approved by EPA prior to January 1, 2012 used the 40% reduction as the baseline loading condition. For TMDLs approved by EPA after January 1, 2012, the 20% reduction serves as the baseline loading condition. The 20% reduction required under s. NR 151.13, Wis. Adm. Code, was to have been achieved by 2008.

For consistency with existing s. NR 151.13 guidance and requirements, the permittee's MS4 permit (MS4 General Permit - see section 1.5.4.4.1) will be requiring that the no-controls modeling condition be used such that the TMDL percent reduction goals will be measured from the no controls modeling condition. Since TMDL development uses the 20% or 40% TSS reduction baseline loading condition, implementation planning will necessitate converting the TMDL stipulated percent reduction back to a no-controls percent reduction for pollutants of concern such as TSS and Total Phosphorus (TP). As identified in the approved Rock River TMDL, a 40% TSS reduction corresponds with a 27% Total Phosphorus (TP) reduction. Based on loading data from the WinSLAMM model, a 20% TSS reduction for MS4s from the no-controls condition corresponds with a 15% TP reduction. This can be done using a mathematical conversion:

For a TMDL that uses 20% TSS reduction as the baseline loading condition (TMDLs approved after January 1, 2012) the conversion to the no-controls modeling condition is:

TSS Percent Reduction (no-controls) = 20 + (0.80 * % control from baseline in TMDL)
TP Percent Reduction (no-controls) = 15 + (0.85 * % control from baseline in TMDL)

For a TMDL that uses 40% reduction as the baseline loading condition (TMDLs approved prior to January 1, 2012) the conversion to the no-controls modeling condition is:

TSS Percent Reduction (no-controls) = 40 + (0.60 * % control from baseline in TMDL)
TP Percent Reduction (no-controls) = 27 + (0.73 * % control from baseline in TMDL)

The above calculated reductions correspond to the percent reduction measured from no-controls as required by the permittee's MS4 permit (MS4 General Permit - see section 1.5.4.4.1). These percent reductions can be compared to the reduction already achieved with existing management practices as required under the permittee's MS4 permit (MS4 General Permit - see section 1.5.4.4.4). This comparison, needed for each reachshed, will determine if additional reductions are needed to meet the TMDL requirements. The MS4 percent reductions from the no-controls condition for the Rock River TMDL and Lower Fox River TMDL are given in Attachments C and D.

For the MS4 area contained in each reachshed, the no controls load is calculated using SLAMM, P-8, or equivalent. The MS4 area includes the entire acreage that the MS4 is responsible for excluding areas not under the jurisdiction of the permittee. As new MS4 area is added or subtracted, the TMDL percent reduction applied to these areas remains the same. The percent reduction from no controls to meet the TMDL is applied to the MS4's modeled no-controls load to obtain the necessary load reduction to meet the TMDL. This load reduction may be different from that needed to meet the stipulated TMDL WLA; however, MS4 implementation of the TMDL is driven by the percent reduction and its corresponding load reduction.

For permittees that elect to use water quality trading or where adaptive management may lead to water quality trading, the load reduction calculated from the no-controls percent reduction should be used when evaluating the necessary mass.

TMDLs do not negate requirements stipulated in s. NR 151.13, Wis. Adm. Code. Therefore, both TMDL percent reductions and s. NR 151.13 requirements must be met. Once an MS4 meets the s. NR 151.13 requirement of 20% TSS control, an MS4 does not need to continue to update their s. NR 151.13 development urban area modeling. This is because s. 281.16 (2)(am)3., Wis. Stats., requires a municipality to maintain storm water treatment practices that are already in place prior to July 1, 2011.

TMDL reports may include both an average annual WLA and a percent reduction for MS4s. For implementation, MS4s should use the percent reduction. The average annual allocations represent the sum of allocations over the year and do not account for the monthly variations in the loading capacity of the receiving water. The percent reductions provided in the TMDL are based on monthly reductions and better reflect the reductions required to meet the water quality standards.

> Example: Appendix V in the Rock River TMDL lists annual mass allocations for Reach 81. The City of Beloit has a baseline loading for TSS of 181.75 tons and a WLA of 259.62 tons (a net increase). However, Appendix I identifies that Beloit needs a 7% reduction in TSS for Reach 81 from the 40% TSS baseline condition. This is because on an overall annual basis Beloit meets its allocation but in certain individual months it does not. The percent reduction is calculated based on the average of the monthly allocations used to determine compliance with the water quality standards.

PART 2 – Implementation and Compliance Benchmarks

Storm Water Management Planning (SWMP)

As described in the permittee's MS4 permit (MS4 General Permit - see sections 1.5.4.4 and 1.5.4.5), DNR will be requiring a TMDL implementation analysis and plan be completed by MS4 permittees subject to TMDL WLAs. This analysis and plan should be incorporated in the SWMP as required by the permittee's MS4 permit (MS4 General Permit - see section 1.5.4). Each MS4 permittee should evaluate all potentially cost-effective alternatives to reduce its discharge of pollutants of concern so that its discharge is comparable to the percent reductions stipulated in the TMDL. MS4 permittees may work together with other MS4s that reside in the same reachshed.

A focus of the SWMP should be on improving storm water treatment for areas of existing development during times of redevelopment. Older, urban development patterns typically did not include the same level of stormwater management controls that new development does. Reductions achieved through redevelopment can be counted towards compliance with WLAs. Each municipality should estimate the pollutant reductions that are expected to be achieved over time through redevelopment of both public and private facilities, including roadway reconstruction. The rate of redevelopment should be estimated in order to provide a gauge as to how long it would take to improve storm water management in areas of redevelopment.

When developing components of a TMDL implementation plan, municipalities should, at a minimum, consider the following implementation methods:

- **Ordinance Review and Updates** – A municipality may elect to revise its current post-construction storm water management ordinance to require greater levels of pollutant control for redevelopment and highway reconstruction that are above the minimum performance standards of ch. NR 151, Wis. Adm. Code and are consistent with the reduction requirements contained in the TMDL.

  Current ch. NR 151 post-construction performance standards for areas of new development include an 80% TSS control level and maintaining 60 - 90% of predevelopment infiltration (with certain exemptions and exclusions). Areas that have stormwater management practices designed and maintained to meet these performance standards should already be controlling TSS and total phosphorus to levels comparable to TMDL water quality targets.

In addition, core provisions in the municipality's SWMP could be strengthened. For example, if bacteria are a pollutant of concern the MS4 may want to place greater emphasis on detecting and eliminating cross-connections between wastewater pipes and storm sewers or stronger pet waste programs.

- **Quantifiable Management Practices** – These practices include, but are not limited to, structural controls such as wet detention ponds, infiltration basin, bioretention, sump cleaning, low impact development (LID), street cleaning and vegetated swales where reductions can be quantified through water quality modeling such as WinSLAMM and P-8.

- **Non-Quantifiable Management Practices –** Quantifiable pollutant reductions may be difficult to determine for some practices such as residential leaf and yard debris management programs, lawn fertilizer bans and information and education outreach activities. This could also include strengthened provisions of the core SWMP. For example, if bacteria is a pollutant of concern the MS4 may place greater emphasis on detecting and eliminating cross connections, stronger pet waste programs and greater focus on elimination of leaching from dumpsters. As data becomes available to quantify reductions the appropriate credit will be given toward meeting the TMDL reduction requirements. In the interim, DNR and the permittee should be able to come to an agreement as to whether the measure is beneficial. In cases where quantifiable reductions are not possible, the use of a non-quantifiable but beneficial practice shall be deemed as making progress toward compliance with the TMDL reductions. The DNR, in consultation with stakeholders, will evaluate these practices as new science and data becomes available.

- **Stabilization of MS4** – Stabilization of eroding streambanks are eligible for a 50% cost share match through DNR's Runoff Management Grant Program. DNR considers streambank stabilization activities an important step in reducing the discharge of sediment. However, TMDL baseline modeling already assumes that drainage systems are stable; therefore, it is not appropriate to take credit against the WLA or percent reduction in the TMDL for stabilization of a drainage ditch or channel of the MS4. However stabilization projects should be identified in the TMDL implementation plan and can serve as a compliance benchmark toward meeting overall TMDL goals.

- **Streambank Stabilization Outside of the Permitted MS4** – Permitted MS4s may take credit through pollutant trading for stabilization of channels and streambanks which are outside of the area served by their MS4. Applicable credit thresholds and trade ratios would apply.

- **Water Quality Trading and Adaptive Management -** If economically beneficial, a MS4 may wish to participate in one of these programs. MS4s are eligible to participate in water quality trading to help meet WLAs. MS4 permittees with areas in the same reachshed can share load reduction credits for practices within those reachsheds using a 1:1 trade ratio. Also a MS4 may be invited by a Waste Water Treatment Facility (WWTF) to participate in an adaptive management program pursuant to s. NR 217.18, Wis. Adm. Code, to reduce phosphorus. Water quality trading and adaptive management guidance are covered under separate DNR guidance documents available on the DNR website.

- **Constructed Wetland Treatment –** Wetlands constructed for the purpose of providing storm water treatment are eligible for treatment credit provided that a long-term maintenance plan is implemented. Wetlands that receive runoff pollutants are expected to, at some point, reach a certain equilibrium point where they would provide minimal pollutant removal or even act as a pollutant source unless they are maintained by harvesting vegetation and/or have accumulated sediment removed from them. Additionally, constructed wetlands installed need to be maintained as stormwater treatment areas in order to maintain their "non-waters-of-the-state" status. Per federal regulations, wetlands constructed as part of wetland mitigation cannot be used for treatment credit.

- **Storm Water Practices and Existing Wetlands -** Wetlands are waters of the state and wetland water quality standards under ch. NR 103, Wis. Adm. Code apply. Additionally, the U.S. Army Corps of Engineers has authority to protect wetlands as well. As such, existing wetlands cannot be used for treatment, however, in limited circumstances storm water practices can be installed in a wetland provided all applicable state and federal wetland permits are obtained. It is often difficult to obtain state and federal permits to construct a storm water treatment facility in a wetland. Contact the local DNR water management specialist to discuss whether this project might be permissible and the associated written justification needed to support a wetland permit application.

As discussed, SWMPs for municipalities with approved TMDLs should identify what pollutant reduction measures will be employed and over what time frame reductions will occur (i.e. 20 tons/yr TSS for redevelopment sites over the next 20 years).

Compliance Schedule and Benchmarks

Once a TMDL is approved, affected MS4 permittees will receive a TMDL implementation planning requirement within their next (or potentially initial) permit term. TMDL implementation planning will include determining storm water management treatment and other measures needed and their associated implementation costs and timelines to achieve TMDL reductions consistent with the TMDL WLAs. It is expected that the following MS4 permit term will include a compliance schedule to implement pollutant reduction measures in accordance with a storm water management plan to meet applicable TMDL reductions.

The compliance schedule will require that the permittee be able to show continual progress by meeting 'benchmarks' of performance within each permit term. In this case, a 'benchmark' means a progress increment – a level of pollutant reduction or an application of a pollutant reduction measure, which is part of a larger TMDL implementation plan designed to bring the overall MS4 discharge of pollutants of concern down to a level which is comparable to the MS4's TMDL WLA. It is possible that certain benchmarks will not be easily quantifiable but there needs to be evidence that such benchmarks will provide a legitimate step toward reducing the discharge of pollutants of concern.

DNR may elect to place specific benchmarks in an MS4 permit. However, it is expected that MS4 permittees will have the primary role in establishing their own benchmarks for each 5-year permit term. Benchmarks should be reevaluated at least once every 5 years and are interim steps/goals of compliance. Where substantial reductions are required multiple benchmarks of compliance will be needed and likely implemented over more than one permit cycle. However, the schedule should lead to meeting the TMDL WLA as quickly as is feasible.

Redevelopment ordinances designed to implement stormwater management controls to achieve compliance with the TMDL requirements are an excellent tool to show progress in meeting the WLA with smart growth and development patterns. Management practices should be installed as infrastructure is replaced. For example, it may be most cost-effective for municipalities to install storm water treatment and infiltration practices as other street or sewer projects are scheduled.

Under a TMDL, EPA does not acknowledge the concept of maximum extent practicable as defined in s. NR 151.006, Wis. Adm. Code, but rather compliance schedules can be structured in SWMPs and permits to allow MS4s the flexibility needed to meet TMDL goals. Any storm water control measures employed by the MS4 permittee to reduce its pollutant discharge to comply with the TMDL reductions will need to be maintained or replaced with comparable stormwater control measures to ensure that load reductions will be maintained into the future.

Runoff Treatment Outside of the MS4's Jurisdiction
In order for an MS4 to take credit for the control of pollutants by another municipality or private property owner (i.e. industry or riparian property owner), the MS4 must have an agreement with the entity with control over such treatment measure. This agreement must specify how the pollutant reduction credit will be shared or otherwise granted to an MS4. Responsibilities for maintenance of the BMPs and preservation of the BMPs over time should also be addressed in any such agreement.

Tracking
The permittee will need to track and show progress in reducing discharges of pollutants of concern. This tracking should assist in showing that MS4 permit compliance benchmarks have been achieved in accordance with an overall storm water management plan to achieve compliance with the TMDL percent reduction targets.

A tabular TMDL compliance summary of pollutant loading per reach will be required to be submitted to DNR with the MS4 report at least once every MS4 permit term. The summary should identify the following: reach name and number (consistent with the name and number in the TMDL report), the MS4 outfall numbers, named/labeled drainage areas, the applicable TMDL percent reduction target(s), pollutant reduction benchmarks, storm water management control measures implemented, and pollutant reduction achieved as compared to no controls. Attachment B is an example of a tabular TMDL MS4 compliance summary.

PART 3 – Modeling

<u>Discussion</u>

The following discussion highlights the main compatibility challenges between TMDL development and MS4 implementation and how they will be addressed.

TMDL waste load allocations are by definition expressed as daily loads. There is flexibility, however, to implement the loads using monthly, seasonal, or annual load allocations. Due to the variability of storm water events and associated pollutant loadings, MS4's have historically used modeling to estimate flows and pollutant loadings using a percent reduction format for the purpose of s. NR151.13 compliance. As part of TMDL implementation, average percent reductions have been developed for MS4s for each reach. These percent reductions generally reflect an average of monthly reductions needed to meet allocations because waters are evaluated against the phosphorus criteria based on monthly sampling protocols. This will allow MS4s to continue using water quality models such as WinSLAMM and P-8 for demonstrating compliance with TMDL allocations. As with s. NR 151.13, TMDL compliance for MS4s will be by design.

Since the modeling tools used to demonstrate compliance with s. NR151.13 pollutant loadings are the same tools used to demonstrate compliance with TMDL pollutant load allocations, much of the existing mapping, water quality modeling, and planning methodologies used for s. NR151.13 compliance can be used or adjusted for TMDL compliance planning.

Generally, the modeling completed as part of TMDL development is at a less detailed scale than the modeling completed by individual MS4s. Due to the scale at which the respective models are completed, it is not unusual to have differences in the drainage areas and the pollutant mass loadings associated with them. Because of the scale at which they are developed, allocations from a TMDL have generally been applied across the entire urban area that is served by the permitted MS4. It is important to note that while many components of existing planning efforts and modeling results can be used for TMDL implementation, adjustments will likely be necessary to account for a TMDL focus on compliance by reachshed.

There may be inconsistencies between the TMDL modeled drainage areas to the actual MS4 drainage areas. Actual MS4 drainage areas may not follow the surface drainage areas and MS4 drainage areas commonly expand due to urban development. For example, the modeled versus actual MS4 drainage areas commonly deviated by 30% and by as much as 60% in the Rock River TMDL. Although these deviations may have a significant effect on a mass wasteload allocation, its affects are greatly moderated on a percent reduction basis across the reachshed. Area deviations commonly affect the MS4 percent reductions by only a few percent. Given the modeling assumptions that have gone into TMDL modeling, deviations by even 10% are within the expected error range of TMDL modeling. Modeling is not an exact science and the TMDL MS4 percent reductions are still considered valid implementation targets to work toward achieving in-stream water quality.

As noted above, MS4s subject to a TMDL should perform analyses and planning to identify cost-effective approaches for reducing discharges of pollutants of concern. To cost-effectively achieve pollutant reductions, MS4s should look for opportunities such as site redevelopment and road reconstruction projects, implementation of streambank stabilization and wetland restoration projects, implementation of traditional BMPs, and possibly water quality trading and adaptive management[2]. Each of these elements can be considered for implementation to meet the requirements of a TMDL. It is likely that existing MS4 water quality modeling and mapping can be used and adjusted as necessary for SWM planning needs for TMDL implementation.

Guidance

TMDL-established WLAs and LAs are 'targets' of treatment performance and/or pollutant control for point and non-point sources. The WLAs and LAs are TMDL modeled estimates of the level of pollutants that can be discharged and still meet in-stream standards. The ultimate goal of a TMDL is for continual reduction of pollutants discharged so that both the listed impaired waters and other waters meet in-stream water quality standards, which would then allow for removal of waters from the 303-d impaired waters list. Municipalities should consider the drainage area served by their MS4 and look for the most cost-effective means to reduce discharges of pollutants of concern until their discharge is comparable with its TMDL requirements.

TMDL Analysis Area

An MS4 is to include all areas within its corporate boundary unless it is listed as optional. Although the MS4 permit focuses on current areas served by an MS4, it may be appropriate to include future land use planning areas.

Incorporation of rural areas: A city or village may have incorporated the entire township or a large portion of the rural township in which it resides. In this situation, the city or village needs to include all areas within the most

2 The Department has prepared separate guidance documents on water quality trading and adaptive management. MS4s are considered non-point sources for the purposes of adaptive management. This does not preclude them from participating in an adaptive management program if approached by a traditional point source such as a municipal or industrial wastewater treatment facility. The "Adaptive Management Technical Handbook" is available for download at http://dnr.wi.gov/topic/surfacewater/adaptivemanagement.html

recent urbanized area, adjacent developed and developing areas whose runoff is connected or will connect to their MS4.

Highways: A permitted MS4 owner/operator of a highway needs to account for the pollutants generated within the Right-Of-Way (ROW). An exception would be a roadway crossing over a highway where the owner of the roadway crossing structure is responsible for the pollutants associated with their bridge and approach structure within the lower highway's ROW. WisDOT is responsible for state highways that are not connected highways. A county is responsible for county highways that it maintains. Cities and villages need to include connecting highways as identified and listed in the Official Highway State Truck Highway System Maps at: http://www.dot.wisconsin.gov/localgov/highways/connecting.htm

Optional: The pollutant loads associated with the following areas are optional for an MS4 to include:

1. Area that never passes through a permittee's MS4 such as a riparian area.
2. Land zoned for agricultural use and operating as such.
3. Manufacturing, outside storage and vehicle maintenance areas of industrial facilities permitted under subch. II of ch. NR 216, Wis. Adm. Code, are optional to include. This does not include any industrial facilities that have certified a condition of "no exposure" pursuant to s. NR 216.21(3), Wis. Adm. Code. *Note: DNR recommends that municipalities include all industrial facility areas within their WLA analysis area instead of creating 'holes' within its area of analysis.*
4. Any area that discharges to an adjacent municipality's MS4 (Municipality B) without passing through the jurisdictional municipality's MS4 (Municipality A). Municipality B that receives the discharge into their MS4 may choose to be responsible for this area from Municipality A. If Municipality B has a stormwater treatment practice that serves a portion of A as well as a portion of B, then the practice must be modeled as receiving loads from both areas, independent of who carries the responsibility for the area. However, if runoff from an area within Municipality A's jurisdiction drains into Municipality B's MS4 but then drains back into Municipality A's MS4 farther downgradient, then Municipality B does not have the option of including the load from Municipality A in their analysis and the load from that area is Municipality A's responsibility.
5. For county and towns, the area outside of the most recent urbanized area as defined by the US Census Bureau. This area is classified as non-permitted urban and part of the non-point source load allocation (NPS LA).

MS4 Water Quality Models and Related Information

To model pollutants such as TSS and total phosphorus in the area served by the MS4, the municipality must select a model such as SLAMM, P8 or an equivalent method deemed acceptable by the Department. For the analysis to show compliance, SLAMM version 9.2 or P8 version 3.4 or a subsequent version of these models may be used.

All roadway right-of-ways within the urbanized area that are part of a county or town's MS4 are the responsibility of the county or town. Model the road based on the urban land use that will most typify the traffic, even if agricultural land use is on one or both sides of the road (for example commercial or residential) and include that area in the corresponding standard land use file.

A municipality is not required to use the standard land use files if it has surveyed the land uses in its developed urban area and has "real" source area data on which to base the input files. The percent connected imperviousness beyond the standard land use files must be verified in the field. Disconnection may be assumed for residential rooftops where runoff has a flow path of 20 feet or greater over a pervious area in good condition. Disconnection for impervious surfaces other than residential rooftops may be assumed provided all of the following are met:

- The source area flow length does not exceed 75 feet,

- The pervious area is covered with a self-sustaining vegetation in “good” condition and at a slope not exceeding 8%,
- The pervious area flow length is at least as long as the contributing impervious area and there can be no additional runoff flowing into the pervious area other than that from the source area.
- The pervious area must receive runoff in a sheet flow manner across an impervious area with a pervious width at least as wide as the contributing impervious source area.

Water quality modeling is a means to determine a storm water management control practice’s treatment efficiency. If the model cannot predict efficiencies for certain storm water management control measures that a municipality identifies as a water quality management practice, then a literature review should be conducted to estimate the reduction value. Proprietary stormwater management control measures that utilize settling as their means of TSS reduction should be modeled in accordance with DNR Technical Standard 1006 (Method for Predicting the Efficiency of Proprietary Storm Water Sedimentation Devices).

When designing storm water management practices, runoff draining to a management practice from off-site must be taken into account in determining the treatment efficiency of the measure. Any impact on the efficiency must be compensated for by increasing the size of the measure accordingly.

Storm water management practices on private property that drain to an MS4 can be given treatment credit, provided the municipality enters into an agreement or has an equivalent enforceable mechanism with the facility/land owner that will ensure the management practice is properly maintained. The municipality will need a tracking system that includes maintenance of treatment practices. An operation and maintenance plan, including a maintenance schedule, must be developed for the stormwater management practice in accordance with relevant DNR technical standards. The agreement or equivalent mechanism between the municipality and the private owner should include the following:

- A description of the stormwater management practice including dimensions and location.
- Identify the owner of the property on which the stormwater management practice is located.
- Identify who is responsible for implementing the operation and maintenance plan.
- Outline a means of terminating the agreement that includes notifying DNR.

The efficiency of a storm water management practice on both public and private property must be modeled using the best information the municipality can obtain on the design of the practice. For example, permanent pool area is not sufficient information to know the pollutant reduction efficiency of a wet detention basin even if it matches the area requirements identified in Technical Standard 1001 Wet Detention Basin for an 80% reduction. Information on the depth of the wet pool and the outlet design are critical features that determine the level of control a detention pond is providing.

Modeling Clarifications

- A TMDL might remove certain internally drained areas from its analysis. If an internally drained area is removed from the TMDL analysis, the MS4 permittee shall not include such area in its MS4 analysis to show compliance with its TMDL requirements. Under this scenario if stormwater is pumped from inside the internally drained area to an external drainage area, then this additional pollutant discharge needs to be accounted for in the MS4 analysis to show compliance with its TMDL requirements.
- Where an internally drained area is included in the TMDL analysis, an MS4 permittee has the option of including this area in its TMDL analysis to show compliance with its TMDL requirements. However, credit for pollutant removal in internally drained areas may only be taken provided the April 6, 2009 DNR Internally Drained Area guidance memo is met with respect to taking pollutant reduction credit within internally drained areas.

- When water is pumped rather than gravity drained from an internally drained area of many acres in area, the MS4 will be expected to use monitoring data to determine the annual average mass of pollutants discharged to the surface water to which the TMDL applies. This does not apply to dewatering covered under a DNR storm water construction site general permit.
- If a portion of a municipality's MS4 drains to a stormwater treatment facility in an adjacent municipality, the municipality generating the load will not receive any treatment credit due to the downstream municipality's treatment facility unless there is an inter-municipal agreement where the downstream municipality agrees to allow the upstream municipality to take credit for such treatment. DNR anticipates that such an agreement would have the upstream municipality assist with the construction and/or maintenance of the treatment facility. This contract must be in writing with signatures from both municipalities specifying how the treatment credit will be shared.
- For reporting purposes, the pollutant reductions must be summarized by TMDL reachshed. Additionally, pollutant loads for grouped drainage areas as modeled shall also be reported. Drainage areas may be grouped at the discretion of the modeler for such reasons as to emphasize higher priority areas, balance model development with targeting or for cost-effectiveness.
- The additional runoff volume from areas that are outside of the analysis area needs to be accounted for when it drains into treatment devices. The pollutant load can be "turned off" but the runoff hydrology needs to be accounted for to properly calculate the treatment efficiency of the device.
- Due to concerns of sediment resuspension, basins with an outlet on the bottom are generally not eligible for pollutant removal based solely on settling. However, credit may be taken for treatment due to infiltration or filtration. Filtration might occur through engineered soil or proprietary filters. Features to prevent scour should always be included for any practice where appropriate.
- Credit should not be taken for street cleaning unless a curb or equivalent barrier is present which leads to sediment buildup on the street.
- To model a combination of mechanical broom and vacuum assisted street cleaning, it may require an analysis of several model runs depending on the timing of the mechanical and vacuum cleaning. If mechanical broom and vacuum cleaning occur at generally the same time (e.g. within two weeks of each other) then only the removal efficiency of the vacuum cleaning should be taken. If the municipality performs broom sweeping in the spring or fall and vacuum clean the remained of the year, calculate the combined cleaning efficiency using the following method:
  (A) Model the entire street cleaning program as if entire period is done by a mechanical broom cleaner.
  (B) Model just the period of time for vacuum cleaning (do not include the mechanical broom cleaning).
  (C) Model the same period as B) but with a mechanical broom.
  (D) The overall combined efficiency would be A + B – C.

WinSLAMM clarification

- WinSLAMM 9.4 and earlier versions of WinSLAMM result in double counting of pollutant removal for most treatment practices modeled in series. WinSLAMM 9.2 and subsequent versions contain warnings to help alert modelers of this issue. The modeler will need to make adjustments to ensure that the results do not include double credit for removal of the same particle size. PV & Associates has created a document titled 'Modeling Practices in Series Using WinSLAMM' which helps to guide a user as to whether and or how certain practices can be modeled in series and this document is available at: http://winslamm.com/Select_documentation.html
- In WinSLAMM 9.4 and earlier versions, when street cleaning is applied across a larger modeled area with devices that serve only a certain area within the larger modeled area, it is acceptable to first take credit for street cleaning across the entire larger area but then the treatment efficiency for other devices must be reduced by the efficiency of the street cleaning to prevent double counting.

P8 clarifications

- P8 does not account for scour and sediment resuspension. DNR requires that a wet basin with less than a 3-foot permanent pool have its treatment efficiency reduced. A basin with zero permanent pool depth should be considered to get zero credit for pollutant removal due to settling and a basin with 3 or more feet of permanent pool depth can be given the full pollutant removal efficiency credited by settling. The pollutant removal efficiency may be given straight-line depreciation such that a basin with a 1.5 foot-deep permanent pool would be eligible for 1/2 the pollutant removal efficiency that would be credited due to settling.
- A device that DNR gives no credit for pollutant removal may still be modeled if it is in series with other practices because of its benefit on runoff storage capacity that may enhance the treatment efficiency of downgradient treatment devices. To do so, turn the treatment efficiency off in P-8.
- P8 should be started an extra year or at least several months before the "keep dates", in order to allow the model to build up representative pollutant concentrations in wet basins.

CREATED:

Eric S. Rortvedt, Water Resource Engineer
On behalf of the Storm Water Liaison Team

10/20/14
Date

Kevin Kirsch, Water Resource Engineer
TMDL Development Coordinator

10/20/14
Date

APPROVED:

Mary Anne Lowndes, Chief
Runoff Management Section

10/21/14
Date

Runoff Management Policy Management Team approved on 9/30/14 (date).

Attachment A: Technical Notes

Establishing relationships between multiple point and nonpoint pollutant sources and their influences on stream flow and water quality is complex. This process is often further complicated by the spatial scale under which TMDLs are developed. In order to help make TMDL development manageable, TMDLs are often developed using large scale modeling approaches that can be difficult to translate to the smaller scale often needed for implementation. For instance, loadings from “non-traditional” permitted MS4s (WDOT and county highways and UW campus systems) are often aggregated with the loadings of traditional MS4s (cities, villages and towns). This loss in resolution can result in inconsistencies in the WLA assignment necessitating a more thorough examination and possible reallocation of a portion of the WLA to non-traditional MS4 permittees.

In many cases where there is an existing TMDL that aggregated WLAs, the Wisconsin Department of Natural Resources (DNR) will need to review, and may need to reallocate WLAs to MS4 permittees. MS4 permittees will then need to conduct storm water management planning to evaluate their current pollutant loads relative to the TMDL reduction goals and create and implement a plan to meet the TMDL reductions.

Whether or not a municipality changes in size or land use, the allowable pollutant load that the receiving water can handle does not change. In the TMDL, the total allowable permitted MS4 load was determined by reach and typically was distributed uniformly across permitted MS4s on a unit area load basis. Since the permitted MS4 allowable unit area load is the same across a reachshed, MS4 WLAs can be reallocated between each other based on area. However, this reallocation must occur at the same time step that was used in the TMDL development process.

> Example: the Rock River TMDL generated allocations on a monthly basis so any reallocation of the WLA between sources must also proceed on a monthly basis. Simply adding the monthly allocations into an annual load and reallocating using an average annual unit load approach will result in a misrepresentation of the TMDL allocations. Analysis must be conducted on a monthly basis.

It is expected that the extent area that will need to be modeled for the MS4 WLA will be larger than that modeled under the s. NR 151.13 (developed urbanized area modeling analysis). This is because the s. NR 151.13 modeling area has many optional and excluded areas, whereas, the TMDL WLA analysis generally lumps all of these areas into the WLA. Also, s. NR 151.13 modeling was based on year 2004 developed area condition versus a TMDL which generally considers most recent development information.

In municipalities that have recently experienced significant growth, there may be a significant increase in urban area. In addition, in some instances the total actual permitted MS4 area within a reachshed is different than that used in the TMDL development process. Initially DNR believed that it would be easy to reallocate a portion of the non-point source LA to the permitted MS4s based on a unit load approach; however, the task can be more difficult than it initially appears. As explained above, the reallocation needs to be conducted using the same time step used in the development of the TMDL and at the same critical flow period used to develop the TMDL. In many cases, this critical flow period used in the development of the TMDL may not correspond with an average annual unit load.

Reallocation Option: In some cases, where TMDL analysis was conducted on an average annual basis it may be appropriate to adjust WLAs based on the acreage associated with each MS4 by reachshed. If reallocating WLAs and LAs within the same reach will still not be adequate to address significant area differences between actual and TMDL modeled reachsheds, DNR will consider on a case-by-case basis as to whether a reallocation between reaches is warranted. For example, an MS4 may collect runoff from a substantial amount of area from one reachshed and discharge it directly into another reachshed.

DNR would include reallocated WLAs in the next reissued permit of affected MS4s. MS4s would have the opportunity to comment and/or adjudicate reallocated WLAs when the permit is public noticed.

Attachment B: TMDL Compliance Summary

TMDL Reach Number & Name: 64 (Yahara River, Lake Mendota & Lake Monona)
MS4 TMDL Percent Reductions needed (no controls): 73% (TSS) & 68% (TP)*
MS4 Existing Controls Percent Reduction (year 2014): 32% (TSS) & 24% (TP)
Modeled MS4 Annual Average Pollutant Load (no controls): 433 tons/yr (TSS) & 124 lb/yr
Modeled MS4 Annual Average Pollutant Load (existing controls): 294 tons/yr (TSS) & 94 lb/yr

Benchmark (BM)	Description of BM Measure	Outfalls Affected by BM control	Affected Drainage Areas (as modeled)	Implementation Date	Measure Treatment Performance	BM % Reduction toward TMDL Reduction	MS4 Cumulative % Control (from no controls)
N/A	Existing control measures	All	All	Ongoing	TSS: 32% TP: 24%	TSS: 32% TP: 24%	TSS: 32% TP: 24%
1	Increased SWM control for Roadway Reconstruction	All	All	1/1/2020	TSS: 60% TP: 40% to MEP	TSS: 0.6% (annually) TP: 0.4% (annually) (30% TSS reduction over 50 years)	TSS: 35% TP: 26% (Accounts for 5 years of reduction)
2	Implement Enhanced Street Cleaning Program	001 003 004 008	1A - 1D 3A – 3K 4C – 4F 8D	1/1/2020	TSS: 12% TP: 8% (no redundant controls)	TSS: 9% TP: 6% (eff. reduced for redundant measures)	TSS: 44% TP: 32%
3	Implement Enhanced Yard Waste Collection Program	All	All	1/1/2021	TSS: 2% TP: 6% (no redundant controls)	TSS: 1.6% TP: 5% (eff. reduced for redundant measures)	TSS: 46% TP: 37%
4	Ordinance Revised – Higher Redevelopment Standard	All	All	1/1/2022	TSS: 60% TP: 40% to MEP	TSS: 0.6% (annually) TP: 0.4% (annually) (30% of TSS reduction over 50 years)	TSS: 49% TP: 39% (Accounts for 5 years of reduction)
5	Retrofit 2nd St. Basin into wet basin	002	B4	1/1/2023	TSS: 60% TP: 40%	TSS: 2% TP: 1% (only serves part of MS4)	TSS: 51% TP: 40%
6	New Wet Basin B15	005	5B - 5H	1/1/2023	TSS: 60% TP: 40% to MEP	TSS: 3% TP: 2% (only serves part of MS4)	TSS: 54% TP: 42%
7	Stabilize MS4 Drainage Ways between X and Y streets	003	3D and 3E	1/1/2024	20 tons/year sediment reduction	N/A Streambank & MS4 stabilization does not count against TMDL reduction requirement	TSS: 54% TP: 42%

* The TSS and TP percent reductions were taken from the Rock River Report's Appendix H and I. All other mass and percent reductions listed are fictitious and shown for example purposes only.

Attachment C: Rock River TMDL MS4 Annual Average Percent Reductions

Reach	Appendix H TP reduction from baseline of 27%	Appendix I TSS reduction from baseline of 40%	Calculated TP reduction from no-controls	Calculated TSS reduction from no-controls
2	29%	1%	48%	41%
3	82%	26%	87%	56%
20	14%	0%	37%	40%
21	10%	0%	34%	40%
23	12%	11%	36%	47%
24	11%	12%	35%	47%
25	64%	32%	74%	59%
26	35%	29%	53%	57%
27	0%	0%	27%	40%
28	1%	0%	28%	40%
29	51%	7%	64%	44%
30	0%	0%	27%	40%
33	29%	9%	48%	45%
34	81%	31%	86%	59%
37	66%	54%	75%	72%
39	0%	0%	27%	40%
45	13%	8%	36%	45%
51	14%	0%	37%	40%
54	61%	6%	72%	44%
55	68%	43%	77%	66%
56	19%	0%	41%	40%
59	54%	15%	66%	49%
60	29%	1%	48%	41%
61	6%	2%	31%	41%
62	70%	70%	78%	82%
63	14%	11%	37%	47%
64	47%	55%	61%	73%
65	49%	46%	63%	68%
66	37%	37%	54%	62%
67	0%	0%	27%	40%
68	52%	18%	65%	51%
69	72%	21%	80%	53%
70	1%	1%	28%	41%
71	29%	31%	48%	59%
72	0%	0%	27%	40%
73	51%	49%	64%	69%
74	17%	20%	39%	52%
75	15%	19%	38%	51%
76	75%	29%	82%	57%
78	4%	0%	30%	40%
79	54%	37%	66%	62%
81	20%	7%	42%	44%
83	37%	25%	54%	55%

Baseline reductions of TP = 27% & TSS = 40% were identified in the RR TMDL report on pages 25 & 27.
% TP reduction from no-controls = 27 + [0.73 x (% TP control in Appendix H)]
% TSS reduction from no-controls = 40 + [0.60 x (% TSS control in Appendix I)]
Reaches that are not listed above did not have a permitted MS4 within the reach.

Table developed by: Eric Rortvedt, DNR Stormwater Engineer
Dated: 9/16/2014

Attachment D: Lower Fox River Basin TMDL MS4 Annual Average Percent Reductions

Sub-Basin	TMDL Report TP reduction from baseline of 15%	TMDL Report TSS reduction from baseline of 20%	Calculated TP reduction from no-controls	Calculated TSS reduction from no-controls
East River	30.0%	40.0%	41%	52%
Baird Creek	30.0%	40.0%	41%	52%
Bower Creek	30.0%	40.0%	41%	52%
Apple Creek	30.0%	40.0%	41%	52%
Ashwaubenon Creek	30.0%	40.0%	41%	52%
Dutchman Creek	30.0%	40.0%	41%	52%
Plum Creek	30.0%	40.0%	41%	52%
Kankapot Creek	30.0%	40.0%	41%	52%
Garners Creek	63.1%	49.9%	69%	60%
Mud Creek	39.0%	28.5%	48%	43%
Duck Creek	30.0%	40.0%	41%	52%
Trout Creek	30.0%	40.0%	41%	52%
Neenah Slough	30.0%	40.0%	41%	52%
Lower Fox River Main Stem	30.0%	65.2%	41%	72%
Lower Green Bay	30.0%	40.0%	41%	52%

Baseline reductions of TP = 15% & TSS = 20%.
% TP reduction from no-controls = 15 + [0.85 x (% TP control in Lower Fox TMDL Report)]
% TSS reduction from no-controls = 20 + [0.80 x (% TSS control Lower Fox TMDL Report)]

Table checked by : Eric Rortvedt and Amy Minser, DNR Stormwater Engineers
Dated: 9/16/2014

APPENDIX E

WDNR Correspondence Regarding Pond D-100 (USH 51 Pond E) Liner

From: Yarrington, Melissa M - DNR [mailto:Melissa.Yarrington@wisconsin.gov]
Sent: Wednesday, May 04, 2016 4:05 PM
To: chrisg@ghidorzi.com
Cc: Scott Turner <STurner@townofribmountain.org>; Arnold, Ryan L - DOT <Ryan.Arnold@dot.wi.gov>; Greg Wagner <gwagner@reiengineering.com>
Subject: 2101 North Mountian Raod LLC, Hilton Garen Inn Site (FIN#56119)

Dear Mr. Ghidorzi,
During review of the application submitted on your behalf for the Hilton Garden Inn Site in Rib Mountain, plans indicated that treatment for stormwater would be accomplished by utilizing a Regional Pond (Pond E) constructed several years ago by the Wisconsin DOT. Please be advised the “as built” drawings obtained by the Department appear to indicate that Pond E is not lined and likely constructed in groundwater and is therefore not in compliance with existing NR 151.

Unless modifications are made to Pond E to bring it into compliance with current code, you will be unable to use it meet your TSS requirements. Alternatively, you are welcome propose other options for meeting your TSS reduction requirements on your existing site.

Sincerely,
Melissa

We are committed to service excellence.
Visit our survey at http://dnr.wi.gov/customersurvey to evaluate how I did.

Melissa Yarrington
Stormwater Management Specialist- Watershed Management
Wisconsin Department of Natural Resources
107 Sutliff Avenue
Rhinelander, WI 54501
Phone: Monday & Friday (715)359-0192; Tuesday, Wednesday, Thursday (715)365-8941
Melissa.Yarrington@Wisconsin.gov

dnr.wi.gov

APPENDIX F

Summary Output Data

Town of Rib Mountain Stormwater Management System Water Quality Treatment Performance

1 = Value from 'regulatory' model
2 = Value from 'Urban area only' model
3 = Value calculated from 'No Area Excluded' mode
4 = Value calculated as "Value 2" x (1 - "Value 3")

							Pond Performance			Swale Performance			System Performance								
													Total Suspended Solids				Total Phosphorus				
BMP Number	BMP Name	BMP Direct Drainage Area (ac)	BMP Regulated Drainage Area (ac)	BMP Cumulative Drainage Area (ac)	Swale Length (ft) only within Urban Area & less than 4% slope	Average Swale Slope (%)	TSS Load	TSS Discharge	TSS Reduction	TSS Load	TSS Discharge	TSS Reduction	Total Load[3]	Regulated Load[1]	Discharge[1]	Reduction[1]	Total Load[3]	Regulated Load[2]	Discharge[4]	Reduction[3]	
A-100	US51 Pond I	1,151.515	720.322	**1,337.151**	82,747	1.40	192616	24854	87.1%	652904	168489	74.2%	950019	690518	24853	96.4%	3528	2272.0	350.1	84.6%	
A-110	Trillium Lane Pond	3.650	0.036	3.650	0	No Swale	23	23	0.0%	No Swale											*No Plans for BMP*
A-120	Flameflow Road Pond	19.999	19.999	19.999	1,095	2.85	10318	10318	0.0%	14219	10318	27.4%									*No Plans for BMP*
A-130	Magnolia Subdivision Pond	20.109	13.423	20.109	1,707	3.01	5601	1580	71.8%	8637	5601	35.2%									
A-140	Trim Crafters	3.720	3.720	3.720	0	No Swale	2008	2008	0.0%	No Swale											*Dry Detention Pond*
A-150	Magnolia Custom Homes Pond	13.664	0.009	13.664	0	No Swale	6	0	92.3%	No Swale											
A-160	Doepke Recreational Area Pond	4.097	4.097	4.097	0	No Swale	2080	2079	0.0%	No Swale											*No Plans for BMP*
A-170	Lily Lane Pond	110.512	12.262	**120.398**	3,269	1.90	8116	8116	0.0%	10553	7720	26.8%									*No Plans for BMP*
A-180	South Mountain Elementary School Pond	9.886	0.000	9.886	0	No Swale	0	0	N/A	No Swale											*Outside, but Upstream from, Regulated Area*
B-100	US51 Pond H	144.289	68.230	**245.286**	11,136	2.18	141645	84148	40.6%	167135	110135	34.1%	350738	248611	84148	66.2%	999.5	638.1	288.5	54.8%	
B-110	US51 Pond G	81.521	39.183	**91.596**	2,615	2.75	48066	16966	64.7%	59390	47666	19.7%									
B-120	Bone & Joint East Pond	0.262	0.243	**1.911**	0	No Swale	582.1	399.4	31.4%	No Swale											
B-130	Bone & Joint Central Pond	1.649	0.118	1.649	0	No Swale	220.1	128.8	41.5%	No Swale											
B-140	Bone & Joint West Pond	8.163	0.000	8.163	0	No Swale	0	0	N/A	No Swale											*Outside, but Upstream from, Regulated Area*
B-150	Texas Roadhouse South Pond	1.298	1.298	1.298	0	No Swale	3250	315.5	90.3%	No Swale											
B-160	Texas Roadhouse North Pond	0.783	0.783	0.783	0	No Swale	1962	1962	0.0%	No Swale											*Dry Detention Pond*
B-170	Dick's East Biofilter	1.248	1.248	1.248	0	No Swale	3226	949.1	70.6%	No Swale											
B-180	Dick's Central Biofilter	0.494	0.494	0.494	0	No Swale	1282	264.2	79.4%	No Swale											
B-190	Dick's West Dry Pond	1.599	1.599	1.599	0	No Swale	4117	4117	0.0%	No Swale											*Dry Detention Pond*
B-200	Wausau Imports Pond	3.501	3.501	3.501	0	No Swale	6,764	6764	0.0%	No Swale											*Insufficient Details in Plans to Model BMP*
B-210	Dunkin Donuts Pond	0.478	0.478	0.478	0	No Swale	918.2	172.9	81.2%	No Swale											
C-100	US51 Pond F	218.929	15.002	**226.619**	2,632	2.13	11993	4457	62.8%	11912	9268	22.2%	94769	16025	4457	72.2%	520.3	58.7	28.1	52.1%	*No Plans for Outlet, Assumed to Match D.S. Culver*
C-110	Freedom Group Pond	7.690	0.026	7.690	0	No Swale	4116	2725	33.8%	No Swale											
D-100	US51 Pond E	507.008	123.343	**637.840**	23,867	1.37	99071	31043	68.7%	156195	90584	42.0%	464569	179885	31044	82.7%	1783	496.3	174.5	64.8%	
D-110	Covantage Regional Pond	128.193	18.556	**130.243**	4,738	1.25	13683	8413	38.5%	17550	10528	40.0%									
D-120	Covantage SW Pond	0.616	0.616	0.616	248	1.39	1523	0	100.0%	No Swale											
D-130	Covantage SE Pond	1.434	1.434	1.434	249	1.61	3225	3156	2.1%	No Swale											
D-140	Szmanda Dental Pond	0.589	0.589	0.589	0	No Swale	1469	73.5	95.0%	No Swale											
E-100	Kwik Trip Pond	2.789	2.789	2.789	0	No Swale	6961	1868	73.2%	No Swale			6961	6961	1868	73.2%	14.3	14.3	5.2	63.9%	
F-100	Goodwill Pond	11.979	11.979	11.979	0	No Swale	13008	1755	86.5%	No Swale			13008	13008	1755	86.5%	31.0	31.0	8.9	71.2%	
G-100	Panda Express East Pond	2.040	2.040	2.040	0	No Swale	3895	3895	0.0%	No Swale			3895	3895	3895	0.0%	8.1	8.1	8.1	0.0%	*Insufficient Details in Plans to Model BMP*
H-100	Panda Express West Pond	1.712	1.712	1.712	0	No Swale	3268	3268	0.0%	No Swale			3268	3268	3268	0.0%	6.8	6.8	6.8	0.0%	*Insufficient Details in Plans to Model BMP*
I-100	AT&T Pond	1.875	1.875	1.875	0	No Swale	4774	2263	52.6%	No Swale			4774	4774	2263	52.6%	10.1	10.1	5.5	45.2%	
J-100	Walmart Pond	32.179	32.179	32.179	311	1.43	61740	61740	0.0%	No Swale			61740	61740	61740	0.0%	130.2	130.2	130.2	0.0%	*No Plans for BMP*
K-100	Sam's Club Pond	9.257	9.257	9.257	1	1.97	17676	17676	0.0%	No Swale			17676	17676	17676	0.0%	36.9	36.9	36.9	0.0%	*No Plans for BMP*
L-100	Nicolet National Bank	2.097	2.097	2.097	0	No Swale	5235	5235	0.0%	No Swale			5235	5235	5235	0.0%	10.8	10.8	10.8	0.0%	*No Plans for BMP*
M-100	Best Buy Pond	12.639	12.639	12.639	0	No Swale	24217	24217	0.0%	No Swale			24217	24217	24217	0.0%	50.9	50.9	50.9	0.0%	*No Plans for BMP*
N-100	Michaels Pond	1.668	1.668	1.668	0	No Swale	3184	3184	0.0%	No Swale			3184	3184	3184	0.0%	6.6	6.6	6.6	0.0%	*No Plans for BMP*
NoPond-1		133.720	121.597	133.720	8,901	2.14	No Pond			51554	31134	39.6%	57423	51553	31133	39.6%	283.1	259.6	173.4	33.2%	
NoPond-2		79.734	20.239	79.734	8,980	1.26	No Pond			38763	14059	63.7%	61811	40899	16196	60.4%	249.7	114.6	56.6	50.6%	
NoPond-3		985.364	955.251	985.364	134,508	1.29	No Pond			1043000	315158	69.8%	1178000	1164000	435686	62.6%	3152	3102.0	1271.5	59.0%	
NoPond-4		8.946	8.946	8.946	663	2.86	No Pond			No Swale			11079	11079	11079	0.0%	26.2	26.2	26.2	0.0%	
NoPond-5		176.212	143.869	176.212	33,071	1.22	No Pond			164830	50502	69.4%	205466	182706	68392	62.6%	632.6	545.1	215.6	60.5%	
NoPond-6		120.699	0.000	120.699	0	No Swale	No Pond			No Swale			0	0	0	N/A	0.0	0.0	0.0	N/A	
O-100	Hobby Lobby Pond	10.962	10.962	10.962	0	No Swale	20928	20928	0.0%	No Swale			20928	20928	20928	0.0%	43.5	43.5	43.5	0.0%	*No Plans for BMP*
P-100	Kohls Pond	10.711	10.711	10.711	0	No Swale	20458	12534	38.7%	No Swale			20458	20458	12534	38.7%	42.6	42.6	28.5	33.2%	*Wet Pond < 3-ft Deep*
Q-100	Ulta Beauty Pond	3.508	3.508	3.508	0	No Swale	6697	1539	77.0%	No Swale			6697	6697	1539	77.0%	13.9	13.9	4.7	66.0%	
R-100	Barnes & Noble Pond	3.536	3.536	3.536	0	No Swale	6751	6751	0.0%	No Swale			6751	6751	6751	0.0%	14.0	14.0	14.0	0.0%	*Plans not available during modeling phase*
S-100	Barnes & Noble Rain Garden	1.362	1.362	1.362	0	No Swale	2600	2600	0.0%	No Swale			2600	2600	2600	0.0%	5.4	5.4	5.4	0.0%	*Plans not available during modeling phase*
T-100	Biolife East Infiltration Pond	0.941	0.941	0.941	209	0.90	154.3	0	100.0%	No Swale			154.3	154.3	0	100.0%	0.6	0.6	0.0	100.0%	
U-100	Biolife West Pond	1.434	1.434	1.434	41	0.70	250.9	0	100.0%	No Swale			250.9	250.9	0	100.0%	1.0	1.0	0.0	100.0%	
V-100	Biggby Coffee East Pond	0.933	0.933	0.933	217	2.46	2328	742.2	68.1%	No Swale			2328	2328	742.2	68.1%	4.8	4.8	1.9	59.2%	
W-100	Honey Baked Ham Pond	1.857	1.857	1.857	0	No Swale	4190	0	100.0%	No Swale			4190	4190	0	100.0%	8.6	8.6	0.0	100.0%	
X-100	Biggby Coffee West Pond	0.913	0.913	0.913	0	No Swale	2154	150.2	93.0%	No Swale			2154	2154	150.2	93.0%	4.5	4.5	0.8	81.1%	
Y-100	Radant Insurance Pond	0.398	0.398	0.398	0	No Swale	954.1	954.1	0.0%	No Swale			954.1	954.1	954.1	0.0%	2.0	2.0	2.0	0.0%	*No Plans for BMP*
YY-100	Howard Johnson's Pond	3.624	3.624	3.624	0	No Swale	7307	7307	0.0%	No Swale			7307	7307	7307	0.0%	15.6	15.6	15.6	0.0%	*Plans not available during modeling phase*
Z-100	Rhyme Insurance Pond	1.147	1.147	1.147	33	0.35	2864	0	100.0%	No Swale			2864	2864	0	100.0%	5.9	5.9	0.0	100.0%	
ZZ-100	US51 Pond D	12.608	12.037	12.608	1,385	1.71	15147	373.5	97.5%	22681	15147	33.2%	205466	22680	373.5	98.4%	632.6	58.9	8.1	86.3%	
	TOTAL	4,083.743	2,432.110	ac	Modeled Swales																

	Total Load[3]	Regulated Load[1]	Discharge[1]	Reduction[1]	Total Load[3]	Regulated Load[2]	Discharge[4]	Reduction[3]
5-yr	3800934	2829550	885968	68.7%	12275.0	8039.5	2979.0	62.9%
1-yr	760187	565910	177194		2455.0	1607.9	595.8	